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PAPERS ON CONSTRUCTION.

No. III.

RELATIONS OF SAFE LOADS TO ULTIMATE STRENGTH.

By Lieut. C. E. Dutton.

(Continued from page 501.)

A comprehensive series of experiments, united with exhaustive theoretical investigation into the relation of safe loads to ultimate strength is greatly needed. Not merely are there wide differences in the practice of the most accomplished engineers in this respect, but even the fundamental principles upon which the various practices are founded seem to be arbitrary rather than rational. In England, where experiences have been wider, and where the economical aspects, certainly, of engineering have been more assiduously cultivated, the arbitrary character of practice is a marked feature. Thus, the Board of Trade regulations prescribe that the working load shall never subject any part of an iron structure to more than five tons of tensile strain per sq. inch. It is obvious that the nearness of this standard to the highest economy will depend, in a great measure, upon several considerations, either one of which may modify extensively its value. First, the resistance of wrought iron to crushing is less than to extension, whether we take its ultimate resistance or its moduli of elasticity. The ratio of these two resistances may be stated at $\frac{1}{2}$, so that if five tons per square inch are just a safe load for tensile strains, they are unsafe for compressive strains; and since, in girders of a symmetrical cross section, these two strains are equal, the fallacy of such a standard becomes apparent. Secondly, the qualities of different grades of iron differ widely both in respect of tensile strength and homogeneity; and, it may be added, in the ratio of tensile to compressive resistance—circumstances whose modifying effect is too plain to need comment. Thirdly, the details and kind of structure may be such that vital parts may be exposed to strains more complicated than simple tensile or compressive stress, the exact nature of which may not be fully ascertained nor contemplated in such an estimate of strength.

Other considerations may also be suggested, which show, in the aggregate, that no such arbitrary standard can insure the highest economy of strength consistent with perfect safety. The wide differences of opinion on this subject may be illustrated by stating that when, a few years ago, it was made a subject of special inquiry by Parliament, Mr. Glynn, in his evidence, recommended that a cast iron bridge should never be loaded beyond one-tenth of its ultimate strength. Mr. Stephenson and other accomplished builders recommended one-sixth, and Mr. Brunel thought one-third, or even two-fifths, a safe margin. Perhaps there is less, much less, difference in the practice of to-day than in that of twenty years ago; the various factors of safety ranging, generally, between one-fourth and one-sixth. But even here it may be fairly asked, how much of this approach to uniformity is merely arbitrary, and how much is founded upon sound theory and carefully considered practical and experimental results. Probably a great deal of the former, and very little of the latter.

With the increased knowledge now possessed of the nature and properties of iron, and its behavior under loads, it would seem that a series of experiments might be instituted with a fair prospect of most valuable results. In the smaller structures, which are thrown up daily in our cities and over streams, the matter may not possess such vital importance, though even here the frequent failures recorded call loudly for reform.

But the tendency of to-day is towards structures which, a few years ago, would have been thought as romantic as air castles, and in these economy possesses a vital importance; indeed, may frequently constitute just the difference between the practicable and the impracticable. With every increase of size the weight of a structure bears a larger ratio to its strength, so that, with given proportions of members, it is easy to calculate the limit at which the whole available strength of it is employed in sustaining its own weight. It is clear, then, that every new acquisition of knowledge which will enable us to determine, with tolerable certainty, the smallest margin of safety, amounts to an extension of the limits of practicability, and to a decided facility in constructions within those limits. We hope to indicate the directions in which theoretical and experimental research may become useful, and the facts which may be made the basis of investigation.

1. The behavior of materials, particularly of iron and steel, under those strains which can be produced experimentally, should be especially and primarily noticed. It seems to us that the use of the ultimate strength of iron, as a standard of reference in determining its available strength, is bad in principle. Ultimate strength, in its general acceptation, means the resistance of a standard bar or rod of the material to rupture by forces applied to it *when new*, and applied, too, during a very brief portion of time, possibly only once. The testing machines usually employed exert their power upon bars of metal fresh from the forge, and rend them by a single effort in a few seconds or minutes. There is, in all this, nothing analogous to rupture produced by protracted wear and tear. We must consider, not merely the well known fact that materials change their molecular structure by time, and the long continued and repeated applications of forces, but that the amount and kind of change so effected, and the exact results upon its strength are quite unknown.

2. Still more pertinent to the case is the fact that the ultimate strength is of little consequence, because no structure must be subject to strains beyond the limits of elasticity. The force under which marked and permanent changes take place in the forms or dimensions of the materials used is necessarily without the limit of safety, for our knowledge of materials assures us that in such a case rupture is merely a matter of time. This lower limit, then, is the only one which practically bears upon the case, and its relation to the higher one of ultimate strength is by no means understood. It is even doubtful whether any definite relation exists at all.

Experiments upon the ultimate tensile strength of materials have been numerous and almost exhaustive. Nearly every book treating of materials contains tolerably complete tables, both of tensile, compressive and transverse strength, determined experimentally. What is far more essential is a reliable table of strains at which these same materials begin to elongate, or collapse into permanent set. To deduce these strains from the ultimate strength is impossible, as the following examples, found in Barlow, will show. The experiments were made by Mr. Brunel.

No.	Began to stretch. Tons per sq. in.	Breaking weight. Tons per sq. in.	No.	Began to stretch. Tons per sq. in.	Breaking weight. Tons per sq. in.
1	21.	29.8	1	28.12	36.12
2	24.	32.	2	27.4	36.4
3	defective	.....	3	24.16	32.16
4	22.	34.19	4	27.16	33.10
5	20.	34.6	5	22.15	31.14
6	20.	28.2	6	25.18	31.15
7	23.2	28.2	7	22.3	31.9
8	24.	31.6	8	21.9	29.6
9	26.9	32.11	9	23.9	31.7
10	23.1	28.12	10	21.9	30.7
Mean,	22.2	30.4	....	24.44	32.3

The iron used was the best Yorkshire, hammered in rods $\frac{3}{8}''$ and $\frac{1}{2}''$ square.

We must here lay down, as well as we are able, what we understand by the limit of elasticity in any particular case. In the preceding table the specimens ostensibly begin to change their forms and dimensions

under a stress somewhere near three-fourths the breaking stress. But it is well known that both wrought and cast iron take permanent set at far lower stresses. Indeed, it is asserted by some eminent authorities that any application of force, however slight, will produce permanent change in iron, though the change may be so small as to escape detection by the most delicate measurements. Allowing this to be true (for there is no intrinsic improbability in it, although it has no practical importance) is there any essential difference between the set produced by the application of twenty tons per inch, and that by the application of one ton, excepting the difference in degree; in other words, is there any essential difference in the nature of the changes produced by the two cases in the molecular arrangement of the material? We venture to suggest that there is an essential difference. It is well established, by many experiments, that iron stretched by weights not exceeding, say, one-third the ultimate strength, resumes *nearly* its original dimensions; but not exactly. The difference is called the set. We are left to infer that this difference is the result of certain molecular changes, but can only surmise their character. Some light may be thrown upon the subject by connecting together the following facts. All varieties of iron consist of agglomeration of minute crystals, octahedral in their fundamental forms, but in most cases also fibrous or minutely acicular, both in cast or wrought iron. The major axes of these crystals have a tendency towards parallelism; *i. e.*, the axes of a considerable portion of the crystals are parallel, or approximately so. In wrought iron this tendency towards, or actual, parallelism is produced by the ductile action of rolling or hammering, compelling the molecules to slide over each other in one direction, during which process they most readily assume the acicular or fibrous structure. In cast iron, also, a definite arrangement takes place in parallel facets, by reason of the escape of heat in particular directions (*i. e.*, in lines normal to the nearest surface of the mass) in passing from the fluid to the solid state. It is not essential to the fibrous condition that all, or nearly all, the crystals should be parallel, but that a considerable portion of them should be so, sufficiently to indicate a tendency to parallelism in a particular direction in preference to any other.

In the case of wrought iron, when the peculiar action of rolling and hammering is considered, it is more than probable that some of the fibers are left in a state of initial tension, and others in a state of initial compression. Under such conditions the application of even a slight degree of force may be sufficient to produce molecular change at points where such tensions exist. In the case of tensile stress, the limit of cohesion between two contiguous atoms may thus be exceeded, and a redistribution of atoms will be most likely to take place by the sliding of other atoms into the interval produced, so that when the stress is removed the tendency to a perfect restoration is resisted at this particular point. In the case of compressive stress, the atoms at points of initial compression may be thrust out of their original situations, and contact effected between atoms which were before separate, and the tendency to restoration after the removal of the stress no longer exists at these points. If we suppose, as is most natural, that these initial forces are of all degrees of intensity between zero and the limit of elasticity, we have here the explanation of the phenomena of permanent set. The effects just described will be approximately proportional to the forces applied. And so we find it very nearly in practice. There are, it is true, departures from the ratio, but not greater than might be expected from the imperfect homogeneity of the metal.

A single application of stress producing a perceptible set, and, according to the views just expressed, occasioning a molecular change in the metal, need not sensibly impair the strength of the iron, for the rearrangement of the atoms may be, and in most instances probably is, as favorable for further resistance as the original one, if not more so. Many repetitions of the stress, however, or the constant action of vibrations during a continuous stress, may produce arrangements less favorable. The tendency to assume the form of large specular crystals seems to be very decided under such conditions, at least, if the strain be tensile. The whole mass being elongated, and the intermolecular spaces being increased, there is afforded, as it were, a sort of facility to the atoms to obey those laws of crystallization inherent in the constitution of all solid matter. Observation and experiment confirm this view.

If there is any measure of truth in the foregoing speculations, it follows that there is a limit of stress at which the cohesive power

of every portion will be exceeded, and a general change in the structure of the mass will supervene. If the constitution of the material is such that the atoms can rearrange themselves readily, the material will behave like a tough, pasty mass, elongating considerably, diminishing in size laterally. If it is strongly crystalline, and the atoms refuse to rearrange themselves, rupture is immediate. The former is the case with good wrought iron, and the latter with cast iron.

In a similar connection Mr. Zerah Colburn remarks, "It would be interesting to know the successive positions of the atoms during the application of the strain. We are, however, without any positive knowledge of the positions which the atoms assume in solidification, and under subsequent forging; but the multifarious forms in which all atoms visibly crystallize serve to show us that they cannot all be at equal distances from each other throughout the whole body. If they were, the arrangement would be that of cannon balls in a triangular pyramidal (or prismatic) pile. Could we visibly represent the atoms as occupying the angles of an infinite number of equilateral triangles we should understand that a linear strain, acting to separate any two of the atoms, would, at the same time, draw a third atom, if not a number of atoms, partly between them. And when, from this intrusion, the repulsive force, always enveloping the intruding atom, had once overpowered the attractive or cohesive force existing between the two atoms thus strained apart, these would, in turn, cohere anew to the atom which had been drawn in between them, and thus we should have a permanent rearrangement of the atoms, or, in other words, a permanent set with permanent elongation in one direction, and permanent contraction in a plane at right angles thereto. That the atoms are thus drawn into parallel rows in many kinds of iron, at least, seems evident from the appearance of fracture, which presents stringy collections of particles, forming what is commonly called fibre, although there is great reason for doubting that anything like fibre existed in the iron before it was broken. Mr. Kirkaldy's recent experiments appear to show, as many others have shown, that iron may be made to break short, or to break with an appearance of fibre, just according as it is broken with a sudden blow or gradual pull."

We attach slight importance to the conclusions from Mr. Kirkaldy's experiments, since they furnish only negative evidence, against which may be cited positive evidence of the strongest kind. They merely show that the fibre is not apparent when iron is suddenly broken. On the other hand, it is not only distinctly apparent when it is broken gradually in the direction of its length, but when pieces cut from a bar transversely are pulled asunder the surfaces of rupture give unmistakable indications that we are obtaining a side view of the fibre. Finally, the strength of wrought iron is from two to four times greater in the direction of the assumed fibre than in a direction perpendicular to it, showing that the arrangement of the constituent particles differs widely in the two directions.

We think some confirmation of the views we have set forth will be found in the fact, that rods of wrought iron, subjected to gradual pulls beyond the limits of elasticity, have their strength not only unimpaired, but actually increased by the strain. If the two fragments of a broken rod be submitted again to rupture, the forces required to effect it in each fragment are almost always decidedly greater than that accomplishing the first rupture. This increase of strength will be found to be more decided in proportion to the softness, or ductility of the iron used. Doubtless the same causes which produce this effect produce also the great increase of strength imparted to iron and steel when drawn into wire. Mr. Barlow gives the results of experiments made at the Woolwich dockyard with reference to this phenomenon, which show an increase amounting, in some cases, to 18 per cent. Mr. Colburn mentions the experiments of Mr. Thomas Lloyd, engineer to the Admiralty, on ten bars of Crown S. C. iron, $1\frac{3}{8}$ inches in diameter and $4\frac{1}{2}$ feet long. The mean breaking weight at the first breakage was 23.94 tons per square inch. At the second breakage the mean strength was 25.86 tons per square inch. At the third breakage it was 27.06 tons per square inch. At the fourth breakage it was 29.2 tons per square inch. The mean strength at the last breakage was about 22 per cent greater than at the first. Mr. Colburn suggests, as an obvious explanation, that the bars first broke at the weakest point, then again at the next weakest, and so on. But this seems to disregard the fact that these bars elongated several inches before breaking, which must necessarily involve a complete rearrangement of its constituent atoms throughout its mass, so that the section of minimum strength was con-

stantly altering, if not its position, certainly its ultimate structure. The process, on the contrary, seems to us quite analogous to wire-drawing, the atoms arranging themselves more and more thoroughly in the form of parallel fibres, which is the position most favorable for tensile resistance, until a maximum of parallelism is reached, and therefore a maximum strength.

Taking into consideration the nature and structure of cast iron, it can hardly be expected that it can be as strong after the application of severe strains as before. Rupture must always ensue whenever the elastic limit is exceeded. A continued repetition of strains ought, upon the foregoing principles, to deteriorate the strength by the successive rupture of the cohesion of detached points. Experience in cast iron guns leads to this conclusion, but exhaustive experiments upon various forms, with stresses variously applied, are much needed.

The following valuable considerations by Mr. Colburn are added: "In a paper of great value, read nearly seven years ago before the Royal Irish Academy, and afterwards published in a quarto volume entitled, 'On the physical conditions involved in the construction of artillery,' Mr. Robert Mallet has laid down a useful measure of the working and ultimate strength of iron. Poncelet had already employed co-efficients, which indirectly expressed, not merely the elastic limit and breaking strength of iron, but the range also, through which the force acted in each case, in reaching these limits. Mr. Mallet has adapted these co-efficients to the English standard of mechanical work, viz, 'foot pounds;' and he represents the structural value of different materials, or of different qualities of the same material, in one case, by the product of the elastic load in pounds into half the range in feet, or parts of a foot, through which it acts, and in the other case by the breaking weight in pounds multiplied also by half the range in feet, or parts of a foot, through which it acts. Mr. Mallet employs Poncelet's co-efficients as follows:

T c = foot pounds in reaching elastic limit of tension.

T r = foot pounds to produce rupture by tension.

T $'c$ = foot pounds in reaching elastic limit of compression.

T $'r$ = foot pounds to produce crushing.

"One-half the weight into the whole extension, or the whole weight into half the extension, is adopted, because the force gradually applied to break the bar must increase from nothing to the breaking weight. Upon Dr. Hooke's law, *ut tensio sic vis*, the weight of a grain will, in some minute degree, deflect or extend the heaviest bar of iron, and the deflection, or extension, will increase progressively with the weight applied, up to the point of rupture. Therefore, if a bar be stretched one foot and then broken with a weight of 33,000 pounds, the work done will be the mean of zero and 33,000 pounds into one foot, or 16,500 pounds. This, as has been said, is the work done in the case of a gradually applied strain. If, however, the weight be applied without impact, yet instantaneously, upon the bar, it will, so long as the limit of elasticity be not exceeded, and supposing the bar to have no inertia, produce twice its former deflection and, therefore, twice the ultimate strain. For the weight, in falling through the distance of the deflection due to the load at rest, will require momentum sufficient to carry it through an additional distance equal to the static deflection. This may be best demonstrated experimentally with the aid of a spring balance. If upon the pan of a balance, sufficiently strong to weigh up to 40 pounds, a weight of 15 pounds be placed, and this be lifted to zero on the scale and there released, it will descend momentarily to nearly 30 pounds on the scale, and were there no opposing resistances, and had the spring no inertia, it would descend to exactly 30 lbs. In the actual application of strains in practice a weight is never thus applied, but a consideration of what would occur under such circumstances is sufficient to show how important it is that vibratory action be not overlooked in considering the strains on bridges. It is to be remembered that this action of suddenly applied loads is only manifested in the case of the application of weights, for if the strain be produced by the sudden admission of steam, or any other practically imponderable body, no additional deflection will take place beyond that due to the pressure acting statically. If steam pressure acted in the same manner, in this respect, as a weight, the steam indicator would show nearly, or quite, double the pressure acting effectively within the cylinder of the engine."

It will not be attempted in the present paper to discuss fully the co-efficients adopted by Mr. Mallet, for there are objections against, as well as reasons in favor, of their

application. It is evident that T r may be the same in two cases, in one of which a high breaking weight is exerted through a very short distance, and in the other of which a low breaking weight produces stretching through a correspondingly greater distance. But this co-efficient does possess a value in taking account of the combined cohesive force and extensibility of iron, instead of the breaking strength alone. Glass has a high cohesive force, but is useless under strain, on account of its brittleness, while india-rubber has great extensibility, or toughness, with but slight cohesion. The products, therefore, expressed by the co-efficients in question do not afford a complete notion of the practical value of a given material, unless the factors whereby these products are obtained are also given. The elastic limit of iron, however low, is not to be exceeded in practical use, whatever its range of elasticity may be; nor does it appear to be prudent to work into the neighborhood of a high elastic limit, when the elastic range is known to be small. It is not to be understood that the co-efficients in question are intended to be applied otherwise than in the comparison of bars of equal length, else it would result that the measure T c, in a bar 50 feet long, was one hundred times greater than that of a bolt six inches long, and of the same material and sectional area. For the purposes of the engineer not only is a long bolt no stronger than a short one, but, as it can be no stronger than its weakest part, it will follow that the average strength of 100 bolts six inches long is likely to be greater than that of a bolt of the same diameter 50 feet long. Every engineer is aware of the importance of toughness in combination with cohesive strength in iron, but we need much more extensive and accurate information respecting the former; and a consideration of Mr. Mallet's co-efficient should lead to additional experiments being undertaken.

Mr. Kirkaldy, proceeding upon an independent course of inquiry, but with the same object as that pursued by Mr. Mallet, published some time ago the results of a series of experiments, which are the first upon any thing like an extensive scale, to take into account the combined cohesive force and extensibility of iron and steel. Mr. Kirkaldy experimented upon hundreds of specimens, but he did not ascertain their limits of elasticity. He has given both the original dimensions and cross-sectional area, and the dimensions and area after fracture, and he has also given the amount of elongation at fracture, although he did not ascertain the amount of extension at the elastic limit. The reduction of diameter of a bar at the joint of fracture serves to give a practical man a good idea of the quality of the iron, but it does not admit of an expression of the mechanical work done in producing fracture, as does the combined breaking weight and linear extension. In tearing a bar in two, also, we have to consider the permanent stretch communicated to all parts alike, and the additional stretch at or near the point of fracture. That part of the stretching which extends uniformly throughout the bar would, we may suppose, be exactly proportional to the length of the bar, while that part of the stretch which takes place close to the point of fracture would, we may also suppose, be a fixed quantity, whatever the length of the bar. Mr. Kirkaldy's specimens of iron and steel varied from 2.4 inches to 8.2 inches only in length, and with these the ultimate elongation at fracture varied from nearly nothing to 27 per cent of the original length, whereas longer bars would have shown a proportionally less elongation. The samples which hardly elongated at all were of puddled steel ship-plates. One sample, which bore 63,098 pounds per square inch of the original area, stretched before breaking but the $\frac{1}{10}$th part of an inch in a length of 7.6 inches, or less than $\frac{7}{10}$ths of one per cent of the length. Adapting to Mr. Mallet's co-efficient, the structural value of such a material would be almost nothing. In fact, Mr. Kirkaldy found the puddled steel plates throughout to have much less extensibility than cast steel plates, and of very irregular breaking strength.

Mr. Fairbairn communicated some of the results of an important series of experiments to the British Association at the Manchester meeting in 1861, from which it appeared that a large model of a wrought iron plate girder withstood, without injury, 1,000,000 applications of a load equal to one-fourth its breaking weight, and afterwards 5,175 applications of one-half its breaking weight, when it broke down. The model was then repaired, and 25,900 applications of two-fifths its breaking weight, and afterwards nearly 3,000,000 applications of one-third its breaking weight were made, it is said, without injury.

The application of iron to bridges, especially to those of large span, necessarily re-

quires the most careful consideration in apportioning the strains, since every pound of metal not brought into effective action is so much dead weight, or useless load, being not only misapplied of itself, but requiring additional material to support it.

The practice among American engineers is very uniform. The factors of safety are almost invariably as follows: For parts subject to constant strain, six; and for parts subject only to occasional strains, four. These figures are factors of *ultimate* strength. The margin of safety has, in all cases, been ample so far as we can learn.

TRACTION ENGINES.

From "The Engineer."

Although the very first carriage ever propelled by steam was constructed years before railways were thought of, and, as a natural consequence, made the first tottering essay at mechanical locomotion on a highway, common roads still remain almost unavailable as a means to locomotion by engine power. A very few years since—a dozen, let us say—an idea sprang into existence that every portable agricultural engine might be, ought to be, and would be made self-propelling, while very large numbers of engines, specially designed, not to drive threshing machines or ploughs, but to haul loads, would be built. Gentlemen like Bray and poor Boydell fostered this idea, and threatened the railways. The railway companies paid not the least attention to the matter. It could be easily proved, they thought, that steam on the common road would never beat steam on rails, and in a sense—and a large sense, too—it is certain that railway companies and their engineers were right in this conviction. The rage for traction and self-propelling engines died out. At this moment it is probable that a smaller number of traction engines is in use than at any other period within the last six or eight years. The number of self-propelling engines—that is to say, of engines intended to take themselves and a plough or threshing machine from farm to farm—is probably much greater, but it must be remembered that from these latter machines railway companies have nothing either to hope or fear; they add not at all to facilities for locomotion, and their abundance or scarcity does not affect the great problem of transporting heavy goods or materials on common highways by using steam instead of horses. With limited exceptions, the traction-engine system has proved a complete failure. It is true that hundreds of traction engines have been built here and elsewhere, and sent to all parts of the world and put to work, and have remained at work till worn out. But this fact is of the smallest importance. If the traction engine had been a success, it would have done for horse haulage what the locomotive did for the stage coach. Instead of hundreds of traction engines we should have built, sent away, and put to work, thousands.

No one disputes that steam might be employed with great success on common roads as means of cheapening the transport of heavy goods or materials of all kinds, such as corn, timber, coal, ores, lime, bricks, and such like; but neither does any one dispute, so far as we are aware, that steam is not so employed either here or abroad, except in a very small and insignificant way, with success. When it can be predicated by intelligent engineers that a given machine ought to succeed, while it can be proved that it does not succeed, a problem is presented, which we, as technical journalists, are bound to consider, and if possible to solve. Let us attempt, then, to solve this question, bringing, we may add, without overstepping the bounds of editorial modesty, at least a little practical experience in traction engines to bear on the matter in hand.

It is very commonly urged that traction engines are not more commonly used because the law concerning them is harsh, repressive, and almost prohibitory. Now even if we granted this statement to be a statement of facts—and we do not—it proves very little for the traction engine builder. It is true that the law prohibits a greater speed than four miles an hour, and orders that each engine shall be preceded when on the road by a man with a red flag, etc. But, in the first place, this rule is not very oppressive, and, in the second, engineers have only themselves to thank for its existence. Traction engines, as they are, are unutterably hideous, astoundingly noisy, and to the last degree offensive in the matter of smoke—not only to horses, but to men. If it could be proved that these conditions are inseparable from the system, then we should have small hopes indeed of the ultimate success of steam on the highway. We believe, however, that the ugliness, noise, smoke, and general nuisance, all result from the great fact that those who have built traction engines up to the present mo-

ment have not realized the importance of getting rid of the specified objections—or, realising it, have been unable to design engines of better construction. A glance at the contents of any agricultural show will prove that the ruling principle guiding the makers of traction engines is to take the ordinary portable engine and adapt it to drive a pair of road wheels. As a result, we have an engine without springs and with all the gearing exposed to the broad glare of day, thumping, and clanking, and grinding, and smoking along our highways. The thing is a nuisance, an unmitigated nuisance, and it is folly to deny the fact. Worse than this, the nuisance is continually getting not only its owners but itself into trouble by breaking down; and all this because a machine specially designed for one purpose is applied to another.

Without engravings it would be impossible to show what a traction engine should be. Perhaps our portfolio of working drawings may yet include one design, disposing of most, if not all, the objections concerning smoke, noise, ugliness, and breakdowns. For the present we shall content ourselves with indicating a few of its features. We have stated that traction engines as they exist are a nuisance, and this in itself is one very sufficient reason why steam on the common road is not a success; but one or two others of even more importance remain to be considered. The first is, that, all things considered, traction engines do not compare favorably as regards the cost of the work done with horses; the second is, that they consume large quantities of water, which cannot always be had, and that even when it can be had, much time is wasted in taking it in. Four miles an hour running time, in all cases becomes three miles an hour including stops to take in water. We have now put before our readers, in one way or another, most of the objections to traction engines. Let us see how they are to be got over.

In the first place, a radical change must be made in the arrangement of the entire machine as compared with those now in use. Instead of the portable engine, we must take the railway locomotive as our model. The first point to be settled is the construction of the machine regarded as a carriage. As the road to be traversed is rough, and machinery does not like rough roads, the two must be kept apart as far as possible. Therefore instead of mounting a boiler half full of water on rigid wheels without the interposition of springs, and a heavy, quick-running engine and fly wheel on top of the boiler, we must provide a rectrangular frame of iron or of oak between iron plates. The frame must be supported on wheels—preferably of wood—through the intervention, not only of springs, but of perfectly efficient and elastic springs, with india-rubber buffing-pieces to take up the last trace of jar and vibration. Next we have to provide a crank shaft running in brasses fixed in wrought iron cheeks—no cast iron except that in the cylinders and a little in the gearing should be allowed in a traction engine—which crank shaft must be driven by a pair of pistons, in order to get rid almost or altogether of the fly wheel—and unnecessary and objectionable excrescence, which should have no more place on a traction engine than it has on a locomotive.

The next step is to provide means by which the crank shaft when revolving will cause the hinder wheels to revolve also. For this there is nothing like a chain, only the chain must not be run too fast, must have plenty of bearing surface, and must admit of being tightened when it gets slack. Various modification of the chain may be used, but we will not stop to consider these just now. If the engine is intended to run at slow speed with heavy loads, intermediate gear must be employed. On the crank shaft a pinion is to be placed gearing into a spur wheel about 3 to 1, and the shaft of this spur wheel—lying across the frames in the rear of the crank shaft—will carry a small chain wheel, while a large chain wheel will be fixed to the boss of one of the road wheels, either or both of which will be fixed at pleasure to the axle. When moderate speeds are allowable the chain pinion may be fixed direct on the crank shaft, which may make nine revolutions for one of the road wheels. If these last are a little under 6 ft. in diameter they will revolve about 288 times per mile, or, at five miles an hour, twenty-four times per minute, which gives 216 revolutions per minute for the engines, the cylinders of which should not be too small in diameter. Ordinarily, steam will be worked expansively in them. By admitting it full stroke, sufficient power may be developed to get the engine up a steep hill or out of a difficulty, at least such a difficulty as will be encountered on a good road—and five-mile an hour engines should not work except on good roads.

The character of the boiler and the position of the cylinders remain to be settled. In any case the crank shaft should be placed

as nearly as possible on a level with the road axle—why, we shall not stop to explain. If the locomotive type of boiler be used, then the clinders go into the smoke box; but under certain circumstances it will be found best to use a vertical boiler placed at one end of the frame, while a water tank is placed at the other, the cylinders being placed vertically between. The use of vertical cylinders will not induce much jump, if any, in a heavy engine; and by adopting the vertical instead of the horizontal arrangement one great difficulty is disposed of. The cylinders and engine can be put near the ground and yet remain accessible and out of the dirt. All the machinery must be boxed-up out of sight.

We have yet to get rid of the waste steam and the smoke. By taking the exhaust through a superheating pipe in the furnace the waste steam may be rendered invisible, and the noise may be completely obviated by discharging from the cylinders into a receiver. As regards smoke, that must be got rid of by the use of coke.* We are unacquainted with any other expedient which will *effectually* prevent the evolution of smoke from the small furnace of a traction engine. Its compulsory use would be no great hardship.

THE SPECTROSCOPE.

From the "American Exchange and Review."

That ordinary or white light may be decomposed by refraction into what are commonly known as the "colors of the rainbow," is a familiar fact. Every transparent substance of greater density than that of air, and bounded by surfaces inclined to one another, gives evidence of this dispersion, as the separation into color is technically called. We see it in the drops that fall from the clouds, in the flashing hues of the diamond, and in the pendants of chandeliers; but it is most conveniently and perfectly exhibited by what is called a prism—a piece of glass having two surfaces greatly inclined to each other. Light, after passing through any of these dispersive media, is no longer of simple and uniform whiteness; it is transformed into a series of the most vivid and delicate tints, melting into each other by an insensible gradation, from a dark heavy red, through brilliant orange, green, and blue, to a deep and tender violet. We are not now concerned with the inquiry, how this diversity of hue is universally found where refraction, or bending of the rays of light, takes place; and whether color is so connected with refraction that every progressive degree of refraction produces its own tint, in which case each hue would be simple and independent; or whether some, at least, of the colors may not be of composite character. The question now seems to lie between a superimposition of three bands of the colors recognized as primaries in painting—red, yellow and blue—equal in extent, but very unequal in intensity in different parts of their length—and a continuous series of literally innumerable hues, each equally elementary and self-subsistent, and each passing, without the least overlapping, into its neighbors on either side by the most delicate and imperceptible modification.

The spectroscope, an instrument invented by Frauenhofer, is destined to take rank with the telescope and the microscope as a revealer of mysteries. Its structure is sufficiently simple, comprising, as its essential parts (for the details are subject to much variation), a slit of adjustable narrowness between two metallic plates, to eliminate the overlapping of the spectra; a prism, or rather, in order to obtain a wider dispersion, a combination of prisms, to decompose the admitted but straightened ray; and a small telescope, the intention of which is to magnify the spectrum thus formed, and rendered sufficiently pure to exhibit its interior arrangement, so as to unfold more effectually its complexity. The investigation conducted by means of this beautiful apparatus is known as spectrum analysis, and it is equally applicable to every kind and degree of light, provided it retains sufficient intensity, after this unsparing reduction and expansion, to form a distinct impression upon the eye.

With the light given out by the terrestrial elements raised to incandescence, a vivid spectrum at once streams from the prism. Any solid element thus ignited affords a band of brilliant colors, but without the crossing of a single dark line. Urge it until it flows down in fusion, still the unbroken spectrum remains; but force on the heat till the material rises into a glowing vapor, and the scene is changed. At once the continuous spectrum, the uninterrupted stream of color, common to every ignited solid or fluid element, is converted into a succession of transverse lines, brilliantly and variously tinted according to their place in the spectrum, extremely narrow fragments, as it

* Or in America by the use of anthracite.

were, of the continuous spectrum, and separated by intervals, more or less wide, of darkness—gaps where that spectrum has totally disappeared. This is strange, and in its first impression strangely irregular; but further examination shows us a yet stranger regularity. There is no rule as to the thickness or position or grouping of the bright lines, but we shall find that every chemical element, whatever its nature, has, when in a state of vapor, a system of lines of its own, and so peculiarly appropriate to itself that the appearance or non-appearance of those lines is an infallible criterion of the presence or absence of that element.

The spectrum, as the band of varied hues is called, when obtained direct from the sun by refraction—whether naturally, as through the bow set in the cloud, or the rain drops pendant on the leaves, or artificially, as through a prism of glass or other suitable material—exhibits nothing more than a succession of brilliant tints passing gradually from red of various qualities, through yellow and green, to blue, deepening into violet. But a little consideration will show us that these colors, however compounded in their own nature. cannot under these circumstances be regarded as absolutely simple and pure. They would be so if the sun were a point; but the breadth of its surface, or, in astronomical language, disc, prevents the complete analysis of its light; for every portion of this disc, from the one side to the other, in whatever direction the refraction may have been effected, has been contributing its own share of light to every portion of the spectrum, so that the latter, instead of being a simple decomposition of one pencil of light issuing from one point, is an overlapping, to a certain small but not inconsiderable degree, of innumerable spectra from an infinite number of luminous points, producing a confusion, the limit of which is, of course, the apparent breadth of the source of light. Within that confusion, that crowding together and intermixture of neighboring tints, some mystery may lie concealed, and fortunately the means are ready to our hand to explain it. We can thin out the crowd to a simple rank by reducing the visible breadth of the sun to a single point. Or, better still, since the tints are mingled and confused only in one direction, that of the refraction, we may, by means of a slit which can be adjusted to any amount of opening, narrow the sun's disc to a mere transverse line of light, which, preserving the full breadth of the spectrum in its own direction, and giving us, as it were, a ribbon dyed in transverse bands instead of the single parti-colored thread which would issue from one point of light, makes the phenomenon conspicuous enough for study, while the confusion arising from overlapping is removed. Thus formed from a single narrow transverse streak of light, the spectrum is no longer a continuous band; its colors remain as they were, but it is full of interruptions; it is crossed in innumerable places—the best instruments show upwards of 2,000—by dark lines, some much broader and more conspicuous than others, but all of hair-like minuteness, and in most irregular arrangement and fortuitous grouping.

The spectrum of the sun is discontinuous, with hair-breadth tracks of darkness. The spectra of the terrestrial elements are also discontinuous, but with hair-breadth lines of light. The one seems of a class which is the reverse of the other; but this apparent contrariety will lead to further thought and further investigation.

The discovery of the true meaning of the solar spectrum, in 1859, was the commencement of a long series of discoveries in solar physics. It had long been noticed that the rainbow-colored streak of light which forms the solar spectrum is crossed by a multitude of dark lines. Some of these lines are well marked, others faint; at one place many are crowded together, at others there are scarcely any; but at all times the same lines make their appearance. For a long time this phenomenon remained without explanation, as also did the correlative phenomenon that the spectra of incandescent vapors consist, not of a rainbow-colored streak, but of a definite number of bright lines. But Kirchhoff, in 1859, made the important discovery which forms the basis of spectroscopic analysis. He found that the dark lines in the solar spectrum correspond to the bright lines of the spectra of incandescent vapors. For example, the double orange line which forms the spectrum of sodium vapor occupies exactly the same place as a well-marked double dark line which appears in the orange part of the solar spectrum; and so with many other similar lines or sets of lines. In fact, he demonstrated that the presence of dark lines in the solar spectrum indicates that the light of the sun shines through a vaporous envelope, and that the vapors which form this envelope are the same which, in an incandescent state in the chemist's laboratory,

produce the bright-line spectra corresponding to certain of the solar dark lines.

To sum up in a few words those principles of spectroscopic analysis which are our chief guide in solar researches: An incandescent solid or liquid gives a continuous rainbow-colored spectrum; an incandescent gas gives a spectrum of colored lines; and an incandescent solid or liquid shining through a vaporous envelope gives a rainbow-colored spectrum crossed by dark lines, and these lines have the same position as the bright lines which belong to the spectra of the vapors which form the envelope.

THE PARIS STEAM ROAD ROLLER.

From a paper read before the Institute of Mechanical Engineers, by Mons. M. E. Gellaret.

This roller consists of a locomotive engine carried entirely upon two large cast-iron rollers of equal size, which are both driven by the engine, the course of the machine being controlled by a special arrangement for changing the direction of the roller axles. The result is that the whole of the weight of the machine is made available both for the rolling of the road and for propelling the machine. The engine is capable of being readily started in either direction without any slipping, and can easily round very sharp curves. This machine is the only one which allows all the weight to be made available for adhesion in driving—an indispensable requisite for a really complete rolling machine—none of the weight being dragged; and machines having only one axle driving are liable to slip at starting, causing damage to the road surface to be rolled, and wasting power. Also, the direction of the motion, whether forwards or backwards, being entirely indifferent, is another essential point for rolling roads. By a special mechanical arrangement the communication of the driving power is maintained direct to both the rollers, however much they may be inclined to each other when traversing a curve; this driving apparatus is made very strong and durable, and it has been found completely successful in work. The weight of the machine is equally divided on the two rollers, and the adhesion for driving is so great that these machines have worked up hills with a gradient of 1 in 12½. They are guided with the greatest facility and certainty on the most difficult and winding roads, by the axles of the rollers being made to converge to the centre of the circle which is being traversed. These machines have now been in regular use in Paris for four years, and the results of their working have so thoroughly established their durability and economy that they are used for the whole of the roads in that city and the suburbs. The machine has a longitudinal wrought-iron frame, like a locomotive engine, with cross bearers to carry the boiler, and a water tank at the back of the footplate. The two large carrying rollers are 3 ft. 10 in. in diameter, and 4 ft. 7 in. in length. They are cast-iron cylinders of 1½ in. thickness, with intermediate strengthening ribs and internal flanges at the ends, to which wrought-iron plate covers are fixed. These close the two ends of the rollers, and have cast-iron bosses in their centres for bearing on the axles. The axles are stationary, and the rollers revolve round them with bearings extending the whole length of the roller, and consisting simply of a cast-iron cylinder, with a continuous bearing on the axle, and furnished with a spiral groove for lubrication. The rollers in the first of these machines were made with separate wrought-iron wheel centres, upon which was riveted a cylinder of boiler plate; but this make was abandoned in consequence of the frequent failure of rivets, which were sheared off by the stretching of the cylindrical plate from rolling out. The present make of cast-iron rollers, heavier than the original wrought-iron ones, but less expensive in make, has proved very satisfactory, and they have done a large amount of work without any expense for repairs, some of them having run as much as 3,000 miles without any sign of cracking or splitting. The first cast-iron rollers were made quite cylindrical; but it was found that the surface became worn down more at the end next the chain-wheel than at the other end; and to meet this irregular wear the rollers have since been cast slightly conical, with the larger end towards the chain-wheel, so that when half worn down they may become truly parallel. One end of each roller has a manhole in it, giving access to the interior for oiling the bearings. There are two sizes of these machines used in Paris—one weighing 15 tons and the other 30 tons in average working order. The smaller one has rollers 3 ft. 11 in. in diameter and 4 ft. 7 in. in length; the rollers in the larger one being 4 ft. 9 in. in diameter, and 6 ft. length. These machines were adopted for rolling the roads in Paris, in consequence of the

satisfactory results of a series of experiments made with them under the direction of M. Michal, director of the municipal service, by M. Homberg, engineer-in-chief of the public roads of Paris. The machines are hired at a fixed charge, which is regulated by the weight of the machine and the distance run in work; the rate being per ton per mile of the machine, 7d. by day and 8d. by night. This rate includes all expenses of wages, coals, and materials for working and repairs, excepting the supply of water, which is furnished by the municipal authorities. The work of each machine is measured by a self-acting counter, indicating the distance traveled, measured at the mean diameter of wear of the rollers; the measurement of distance being taken only during the actual time of rolling, with an allowance added of three miles for traveling to and from the place of work. The work is, as a general rule, done in the night within the city, the portion of road repaired during a night being completely finished by the morning ready for traffic. The speed of working is from $1\frac{1}{2}$ to $2\frac{1}{2}$ miles per hour, being limited to the latter amount by the public regulations. The usual practice in repairs is to lay down a layer of broken stone about $2\frac{1}{2}$ in. thick at the sides of the road, and 6 in. thick in the middle; the surface of the road being generally picked up previously. The rolling engine commences work at the opposite sides of the road; alternately traveling backwards and forwards over a length of about 100 yards, and working its way gradually to the middle of the road, when it proceeds to roll another similar length. The layer of broken stones is watered from the street mains, and binding material, consisting of road scrapings, is put on before the rolling. There is not the slightest difficulty experienced in reversing the motion of the rolling engines, and they start in either direction without any slip whatever, and the broken stone is regularly rolled down without getting pushed up or driven before the rollers. The engines start with great facility, even on a considerable incline, and they turn easily in a circle of only 13 yards radius. In making new roads the broken stone is usually laid down in a single layer of 10 to 12 in. in thickness, and this thickness of material can be satisfactorily rolled. The total distance traveled per day of ten working hours by one engine is usually from 15 to 20 miles. In working, two men are employed for the smaller engines—an engineman and a steersman, and for the larger engines a fireman in addition, for the purpose of oiling upon the road without stopping the engine. The mean power developed by the larger engines is about twenty horse power. It is often below that amount, and then sometimes rises to thirty or even thirty-five horse power. The engines keep well in order, and run from 1200 to 1800 miles before requiring any important repairs. They are made very strong; the axles, chains, pinions, and working gear being made of steel, and the engines of the quality of best locomotive work. They are consequently expected to keep at work fully ten years. In reference to the relative cost of rolling roads by the steam roller or by horse power, the following facts may be taken as a comparison of the prices per ton per mile by each plan. The result of numerous data shows the cost of horse rolling in Paris (including horse keep, drivers, and oiling) to be 11d. per ton per mile, or about $11\frac{3}{4}$d. including cost of repairs. The addition of interest of capital and depreciation would raise the total cost to about 14d. per ton per mile. On the other hand, for the steam rolling the actual payment is only half that amount, or 7d. per ton per mile, including the contractor's profit; so that there is a great economy as regards cost of power in the steam roller. The advantages of the steam roller over those drawn by horses are, economy in the cost of the work, rapidity of execution, and greater perfection in the work done; the durability of the road surface being found to be at least doubled where the steam rolling has been well done, as compared with roads not so rolled.

ON THE INFLUENCE OF SEVERE COLD ON METALLIC TIN.—Fritzsche, of St. Petersburg, communicated to the Paris Academy the interesting fact that during the severe cold of last winter, in St. Petersburg, large blocks of Banca tin became crystalline through the whole of their mass. They now contain in their interior, hollow spaces of up to 100 cubic centimeters. The walls of these hollow spaces are smooth and shiny. The other parts of the tin which have been transformed partly into small crystalline grains, partly into brittle pieces of various sizes, have a dull appearance, caused probably by superficial oxydation.—(*Compt. Rend.*, t. 67, p. 1106.)

LIGHT VS. HEAVY LOCOMOTIVES.

ROLLING STOCK ON THE METROPOLITAN RAILWAY.

From "The Engineer."

Those who are interested in the often-discussed merits of light *versus* heavy rolling stock, will find just now much deserving of their attention in the working of the Metropolitan Railway. They may there see some of the lightest tank engines and carriages recently used for main line traffic, working side by side with the heaviest stock ever put on any line. A very important problem, therefore, bids fair to receive a speedy solution on the Metropolitan Railway; and the solution will, unquestionably, possess every characteristic which can render it absolutely final under the prescribed conditions. In a word, a most valuable experiment is being tried on the largest scale; and the result, be it what it may, must be accepted as conclusive. The facts may be stated in a very few words, but they will be all the better for a little explanation.

The first engine designed to work the Metropolitan Underground Railway, was fitted with air pumps and an injection condenser. Its weight was something enormous, and its performance so unsatisfactory that we believe it never ran a single passenger train. The line was first practically worked by the Great Western Railway Company with broad gauge engines, having outside cylinders and six wheels, four of them being coupled. These engines did very fairly, and are now in use down the country. Next came an interregnum, when the traffic of the line was conducted by the Great Northern Railway Company with their ordinary narrow gauge mixed engines, blowing their waste steam into the tender through a temporary exhaust pipe. Meanwhile, Mr. Fowler prepared designs for new narrow gauge tank engines. These engines being specially designed to work underground, possessed not a few novel features. Twelve were built in the first instance by Messrs. Beyer and Peacock, and, as a natural consequence, the work is simply faultless. We cannot say as much for the design. It was of the utmost importance that the engines should get away quickly with their trains, yet the driving wheels are 5 ft. 6 in. in diameter, a dimension rendered inexcusable by the fact that only a moderate speed was demanded. In order to compensate for the size of the wheels, and to still retain the great tractive force, essential to rapid starting, large cylinders were of necessity adopted. We need not stop to explain how great an augmentation of weight this entailed. It was next assumed that the curves would be bad to get round with a six-wheeled engine, therefore a bogie was introduced principally because the engine was made too long to begin with. This farther increased the weight, and so, finally, Mr. Fowler produced the now well-known narrow gauge standard Metropolitan engine, weighing nominally 42 tons, but in all probability at least 45 tons loaded. This monstrous machine is employed to haul trains consisting of five not less monstrous carriages, carriages mounted on eight wheels disposed in two groups, and weighing 16 tons each. We have thus a locomotive weighing 45 tons hauling a train weighing 80 tons, carrying, when full, 20 tons of passengers or so, at a speed of 25 miles an hour, over the best permanent way ever laid down: gross load, 155 tons; paying load, 20 tons, or less than half that of the engine alone. There are no exceptionably heavy inclines to be surmounted, and the bad curves are few in number, and at the worst do no great harm, because the speed at which they are traversed, as at King's Cross, for example, is low. We fancy that every unprejudiced engineer, with these facts before him, will admit that Mr. Fowler's engines are not the best that can be designed for the intended purpose, and that, all things considered, they are apparently very much underworked. The driving wheels are much too large, the machine too long, and, above and beyond all, the enormous weight of the engine constitutes a grievous defect. There is no denying the fact that the standard engines play havoc with the permanent way of the Metropolitan Railway, smashing off the tables of steel rails, and grinding out the best Bessemer track, perhaps in the world, as though it were made of iron.

Mr. Fowler has gone on adding to the original stock of twelve engines with others built off the same patterns; but we find that neither the Great Northern, the Midland, nor the Great Western Companies have followed his example. The Great Western Company put on some broad gauge engines with six very small coupled wheels and inside cylinders, three or four years ago; these have been abandoned with the broad gauge. The Great Northern Company, in working steeper inclines than any which the Metropolitan engines are called on to traverse,

adopted a design differing widely from Mr. Fowler's. The Great Northern engines weigh full but 33 tons. They have four coupled wheels, 16-in. cylinders, and a pair of trailing wheels mounted with Adams' radial axle boxes. These engines gave great satisfaction. Next came the Midland with a modification of Mr. Fowler's design, the engines weighing much less, however. And, lastly, we come to the rolling stock put on by the Great Western Company within the last few months, which is the very antithesis of Mr. Fowler's. Now, if the designs of the latter gentleman had been proved to be right by the results of three years' working, how is it, we may ask, that the engineers of other companies have not followed his example or endorsed his practice by adopting his typical engine and carriages? The fact that they have not, is the best possible proof that Mr. Fowler made a great mistake when he designed his standard rolling stock for the underground railway.

We do not propose here to say anything more of the methods adopted by the Midland and Great Northern Railway in working their metropolitan traffic. We shall confine our attention to the new engines and carriages used by the Great Western Railway Company in working their local traffic between Windsor, Ealing, &c., and Moorgate street, since the abandonment of the broad gauge between Bishop's road and the City. The engines resemble those used by the Midland Company in working their metropolitan traffic, but they are rather smaller, and certainly more elegant. They have flush boilers with a very small central dome, a pair of side tanks, and a condensing arrangement very similar to that used in the standard engines. They have six wheels, four of them being coupled, and inside cylinders. These engines weigh full, one with another, as nearly as possible 32½ tons, or from 11 to 12 tons less than Mr. Fowler's engines. The average train drawn consists of six light carriages, but this in no way represents the capacity of the engines. In the early part of the day the trains are much longer; and on several occasions fourteen carriages have been taken from Windsor to Paddington, a distance of about eighteen miles, in a little over twenty minutes. We have carefully timed these engines when getting away with their trains, and found them to be quite as expeditious as Mr. Fowler's engines, perhaps a little more so. In every respect their performance is most satisfactory. We have, then, in few words, the Great Western Railway Company doing the same work that the Metropolitan Railway Company are doing, with a dead weight less at least by 25 tons per train, if we assume ten of the Great Western carriages to carry only as many as five of the Metropolitan carriages.

It remains, of course, to be seen how the Great Western light stock will work out in continuous practice; so far, it leaves nothing to be desired. The carriages, though small, are lofty and comfortable; they are not as yet disfigured by hideous advertisements; perfect time is kept, and a carriage or two being easily added or taken off, as may be necessary, the trains are, as a rule, fairly filled, without being overcrowded. If Mr. Fowler's method of working metropolitan traffic can be made to pay—and it is—then much more should the Great Western system pay. In the case of the engines alone, the cost of transmitting each ton of dead weight from place to place cannot be much less than 2d. per ton per mile. Taking the very moderate estimate of 20,000 miles as the distance run each year by each engine, we have a saving on 12 tons less in the Great Western engines, as compared with the standard Metropolitan engines, of £166 per engine per annum, or for the Metropolitan Railway Company, with 36 engines, a saving of, in round numbers, £6,000 per annum; while, if we regard the smaller weight of the carriages, and the increased durability of the permanent way, due to the use of light rolling-stock instead of heavy, we shall find that the saving may possibly reach double the sum we have named.

CAST-IRON FORTS.

From "Engineering."

In these days of Shoeburyness trials, when almost every conceivable combination of iron and steel capable of forming a target has been subjected to hammering by shot and shell, with more or less satisfactory or unsatisfactory results, it is something to come across the proposal of a really novel, and at the same time promising, system of fort construction. We have had shields formed entirely of wrought iron, shields of iron with wooden backing, shields of iron and steel, granite casemates with iron shields, and a host of other devices, and now we have Mr. Thomas R. Crampton's proposal to make forts of cast iron. Not a very promising

material some of our readers will say; and we must own that except it be employed in the way Mr. Crampton proposes, they are right. The proposal to use cast iron as a material for constructing shields or defences is not new, and Mr. Crampton lays no claim to it; but what he does claim is the plan of constructing forts by casting them *in situ*, either in one single piece or in blocks of large size, each weighing not less than 200 tons or so. Forts thus constructed would afford very different resisting powers to defences built of cast-iron blocks weighing three or four tons each, such as have been in some cases proposed; and although we have no data from which we could calculate what the resisting power of such massive blocks as Mr. Crampton proposes to use would be, we are, we think, justified in stating that the system is worthy of a trial.

That there would be no great practical difficulty in constructing such forts is certain. The process would be merely an extension of that which has been so successfully carried out by Mr. Ireland in a number of instances, when large anvil blocks have had to be cast. All that would be requisite would be to prepare the necessary foundations, and construct *in situ* a mould of the required form, this mould being either made of brickwork, or of a combination of brickwork and iron framing, according to the circumstances of the case. Around the mould would be arranged, in convenient positions, a series of cupola furnaces, the number of these furnaces being regulated by the size of the casting to be produced and the time allowed for completing the operation. Mr. Ireland has, as we have said, produced a number of large castings by a similar method, and about eighteen months ago (*vide* page 496 of our fourth volume) we described the casting in this way of an anvil block weighing 210 tons at the Bolton Iron and Steel Works. The metal for this block was run from two cupolas in 8¾ hours actual working time, and the casting proved perfectly successful. Judging from the experience already gained, there appears to be practically no limit to the size of the castings which can be produced on this system, and we feel certain that Mr. Crampton would have no difficulty in casting his forts, as he proposes, in solid blocks, weighing 5,000 tons or so, if occasion should require it.

We have said that we have no data as to the resistance to shot afforded by cast iron in large masses; but we are inclined to think that it would be satisfactory. Mr. Crampton, however, does not confine his plan to the application of cast iron alone; but he states that the metal may be strengthened by melting up scrap iron with it, or in some cases the castings may be formed of steel or iron produced by the Bessemer process. Whether it would be possible to apply the Bessemer process to the satisfactory production of such gigantic masses we cannot say, but we have no doubt about the possibility of producing them in plain cast or toughened cast iron. In the case of the cast-iron forts being of such form as to require portholes, Mr. Crampton proposes to guard each opening by the insertion in the casting of a massive block of wrought iron or steel of suitable form.

As for the expense of constructing such forts as we have above described, Mr. Crampton estimates that a cast-iron structure might be made six or seven times the thickness of a built-up wrought-iron structure of the same total cost; and considering the high price of heavy wrought-iron armor plates, we do not think that this estimate is an unreasonable one. All events, we think that our government authorities might do many worse things than test the effect of shot and shell on a 200-ton block of cast iron.

LIQUID FUEL IN METALLURGY.

From the "Mechanics' Magazine."

The advantages of liquid fuel, when properly used, over coal, for steam purposes, have long since been fully demonstrated, and they stand unquestioned. Hitherto, the endeavors to utilize mineral oils have been chiefly confined to the furnaces of boilers; but now we have another eminently successful application of the oil furnace to metallurgical purposes. Our readers can hardly have forgotten the successful trip of the "Retriever," a steam ship of 500 tons burden, which was fitted up on the system of oil furnace invented by Mr. Dorsett, of London.* This system consists in burning in the furnace the vapor of creosote, which is produced in an auxiliary boiler. Having established the success of the principle in one direction, Mr. Dorsett conceived the idea of utilizing it in another—that of heating iron plates for bending. The idea was first put into execution about four months since, when Mr. Dorsett obtained permission to apply his system of burning liquid

* Van Nostrand's Magazine, No. 1, p. 57.

fuel to a plate-burning furnace in Woolwich Dockyard. This was for plates of the ordinary thicknesses used in iron shipbuilding, and the results were so satisfactory that the authorities directed the principle to be applied to an ordinary plate-bending furnace and to an armor-plate furnace in Chatham Dockyard. It is to the latter of these we wish to direct special attention, as being a great triumph of the Dorsett principle of burning liquid fuel.

Under ordinary circumstances, the armor-plate bending furnace is lighted from four to five hours before the plate is placed in it. The time occupied in heating the plate for bending depends upon its thickness—one hour per inch of thickness being allowed. Taking, then, a 6-inch plate—as upon the present occasion—we get from ten to eleven hours from the time of starting before the plate is ready for bending. Let us now see what the liquid fuel will do. Upon our visit to Chatham, the cold furnace was lighted, and after an hour was deemed sufficiently heated. A 6-inch armor-plate, 7 ft. 6 in. long by 3 ft. wide, was then consigned to the furnace, and after an hour and a-half was drawn out thoroughly heated and ready for bending. Thus, in two hours and a-half we have the work of ten or eleven hours completely and satisfactorily performed. Nor is this all; the advantages of the system do not stop here. The plate was remarkably free from scale, which can only be accounted for by the absence of the deteriorating influence of the products of combustion in the ordinary furnace. Another valuable result arises from this same cause; thinner plates, when heated by liquid fuel and bent double, show no signs of cracking, as they usually do when they have been heated in the coal furnace. This important feature is reckoned to save ten shillings per ton on the metal, which amount it would lose in value by deterioration under the ordinary method of treatment. The vaporized creosote is supplied to the furnace under notice from the generator by six jets, which are led in through small openings, by which means also just a sufficient quantity of atmospheric air is admitted to support combustion. This method of supplying the heat also offers another advantage; it can be applied to the whole or any portion of the plate. Thus, if a plate requires to be bent at one end only, then the heat is directed to that part. Further, the rate at which the metal is heated can be regulated to a nicety by either increasing or diminishing the number of jets. The consumption of oil at Chatham is 108 gallons per furnace per day.

Close beside the armor-plate furnace is another one for heating thinner plates, and which has been regularly at work for some time past. It is heated by four jets, and is supplied from the same generator as the larger one, and which is placed between the two. On the occasion of our visit some half-inch plates were being heated and bent to various templates. The average time occupied in heating was seven minutes; with the ordinary furnace it takes from twelve to fifteen minutes for each plate. As already stated, the heating of the 6-inch plate was only experimental and preparatory to a regular course of practical work which is about to commence. But it was an eminently successful experiment, and, moreover, was not the first made in the same furnace. The plate in question had been through the same process three times previously, although its clean, smooth surface would not have led to that supposition, for it had the appearance of having had nothing done to it since it left the rolls. The future work of the furnace will consist in heating the armor-plates for bending for the "Sultan," a vessel of 5,226 tons burden, now constructing. In this furnace we have another practical evidence of the value of liquid fuel when utilized in the form of vapor. In its working we have some of the most remarkable and unlooked-for results, which, while they fully satisfy us for the present, only lead us to expect further and even more important improvements in the application of the system.

THE BESSEMER STEEL WORKS AT TROY.—The two-ton plant of Messrs. John A. Griswold & Co. is in constant operation, producing some 300 tons of rail ingots per month. The walls and machinery of the new five-ton plant (to replace that destroyed by fire in October last) are nearly completed, upon an enlarged plan. The roofs, furnaces and smaller machinery, are yet to be placed. The new blowing engine, the largest in this country, is nearly ready to run. This company are prepared to take orders for rails for spring delivery, and will be able to execute them upon the completion of the new plant this fall, at the rate of 1,800 to 2,000 tons per month. They are also prepared to furnish rolled bars and shapes in steel, having erected a heavy mill for this special purpose.

ON RIVETS AND RIVETING.

BY MARTIN BALCKE.

Translated for Van Nostrand's Magazine from Polyt. Centralblatt.

The following remarks do not refer to riveting for the purpose of merely uniting two parts of machinery or two sheets of iron, but they apply to rivetings which require a higher degree of strength and solidity, as, for instance, for boilers and working parts of machines. It is a general rule for all constructions, especially for those in iron, to distribute the strain which has to be withstood by a certain part of a machine, as evenly as possible over the solid mass of the said part. This rule is also very important in the use and arrangement of rivets. The simplest and safest way to carry out this rule is to calculate directly the areas of the working sections, and to see that the strain which acts on any part of a section, does not exceed certain limits generally conceded to the respective materials. This is the way, also to avoid the use of empirical formulæ, the most important coefficients of which are always dictated by the personal opinions and notions of their authors.

The force necessary to tear a wrought iron bar of a certain section, is so nearly equal to that required for cutting or shearing the bar, that both may be considered as equal in calculations, for practical purposes. The limit of elasticity of soft wrought iron, as generally used for rivets, is at a pressure of about 18,000 lb. on the square inch. With boilers the strain of tension per square inch of section of the material, ought not to reach 9,000 lb.; because continued heating and long use weakens the material considerably. In the construction of stationary boilers, one square inch of section, taken through the riveting, ought generally not to be strained above 12,000 lb. But if a riveted part of a machine has to sustain a strain acting alternately in two different and opposite directions, this strain should never exceed 2,000 lb. per square inch of section.

If a quite uniform distribution of the strain over all the sections cannot practically be obtained, at least the tension of the sections which are exposed to the highest strains ought to be kept within the above-mentioned limits.

The shape of the head of a rivet is dependent on the kind of strain to which the rivet is subjected. This strain can have the tendency of tearing or of shearing the rivet, or of both simultaneously. If a rivet has to withstand a tearing strain, the height of its head must be such that the cylindrical surface which would make its appearance when the head of the rivet would be stripped off, is equal to the area of a cross-section through the rivet. If we denote the height of the head by the letter h, we obtain the equation:

$$2r\,\pi \times h = r^2\,\pi,$$

which gives us—

$$h = \frac{r}{2};$$

that is, the height of the head has to be one-half of the radius, or one-fourth of the diameter of the rivet.

Practical experiments on the strength of rivets have come to the same result, and have besides shown very distinctly that the rivet-holes should never have sharp edges, and that the head of a rivet ought to be connected with the shaft by a conical part. Whenever this part is omitted, and when, consequently, the rivets have sharp corners below their heads and the rivet-holes sharp edges, the rivets break close to the head, when subjected to a strain of tension and when the heads are strong enough not to be stripped off. When, on the contrary, the rivets have a conical connecting part between their heads and shafts, they extend considerably before they break, and the rupture finally occurs in the middle of the shafts. All experiments have given this result without exception.

Rivets subjected to a shearing strain only, would theoretically not require any head at all. But it is good, also, in this case to make the heads of the rivets as high as above determined, because generally a close contact of the riveted parts is desirable, and because the rivets, being set in red-hot, have to resist the strain of tension produced by their contraction in cooling.

If the heads of rivets have to be countersunk, their best shape is that of a truncated cone, the angle at the point of which cone would be of 75 deg.

The sectional area of the shaft of a rivet, expressed in square inches, is found by dividing the actual and total strain on the rivet, by the strain practically admissible on the square inch of the respective material.

We will now examine the riveting of simple round boilers. We designate by D the diameter of the boiler, by P the steam pressure per square inch, by t the distance between the rivets, by p the shearing strain on

every rivet in the length-row. Thus the strain to which the boiler is exposed on every rivet-distance of its length, is expressed by $D \times t \times P$, and as this strain is divided on the two opposite sides of the boiler, we obtain the formula for the shearing strain on a rivet:

$$p = \frac{D \times t \times P}{2}.$$

The strain on a rivet-distance of the rows round the boiler, is measured by a triangle whose base would be the rivet-distance, and whose height the radius of the boiler. Consequently the strain on every rivet of the rows round the boiler is expressed by the formula—

$$p = \frac{D \times t \times P}{4}.$$

Now, to obtain an even distribution of the total pressure in the boiler over all its sections, the sectional area of a rivet has to be equal to the sectional area of the plate between two rivet-holes, and equal also to the double area of a section through the plate, from a rivet-hole to the edge. If we call a the thickness of the plate, d the diameter, and q the sectional area of a rivet, we obtain the formula—

$$q = (t - d)\,.a, \text{ or } t = \frac{q}{a} + d,$$

from which we conclude that the rivet-distance is dependent on the diameter of the rivets, and, reciprocally, the diameter on the distance. To determine these, it is necessary to take into consideration the possibility of making and keeping the boiler tight, which possibility depends principally on the relation between the thickness of the plate and the rivet-distance. Let us consider a special case to explain this more fully. We suppose a simple cylindrical boiler to have a diameter $D = 42$ in.; the thickness of the plate, $a = 0.3$ in.; the excess of the steam pressure over the atmospheric pressure, $P = 42$ lb. Under these conditions the strain of tension per square inch of plate-section, taken parallel to the axis of the boiler, is—

$$\frac{D}{2} \times P \times \frac{1}{a} = \frac{21 \times 42}{0.3} = 2{,}940 \text{ lb.}$$

In taking the areas of the rivet-sections equal to those of the plate-sections contained between two rivet-holes, according to the above rule, and in calculating the following items for three different rivet-diameters, for the sake of comparison, we find—

The rivet-diameter being . .	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.
Area of rivet-section (sq. in.), q =	0.307	0.442	0.601
Distance between rivets (inches), $t = \frac{q}{a} + d$ . . . . . =	1.648	2.22	2.878
Shearing strain on a rivet (lbs.), $p = \frac{D \times t \times P}{2}$ . . . . =	1,453	1,959	2,538
Strain per square inch on a section through the plate, or through the rivets in the length-rows of the boiler (lbs.) $= \frac{p}{q}$ . . =	4,730	4,430	4,220
[The shearing strain on rivets and the strain per square inch of section in the rivet-rows *round the boiler*, are one-half of those in the length-rows.]			
The strength of the riveting compared to the strength of the simple plate $= \frac{t - d}{t}$ . . . =	0.62	0.66	0.70

The advantages and disadvantages of the one or other of the chosen rivet-diameters are clearly shown by these tables. The $\frac{5}{8}$ inch rivets produce a very small comparative strength of the riveting (0.62). The $\frac{7}{8}$ inch riveting has a great comparative strength; but the distance between the rivets (2.878 in.) is too large in proportion to the thickness of the plate, to allow of a good and safe tightening of the joints. The $\frac{3}{4}$ inch rivets, not showing either of the two mentioned disadvantages in a considerable degree, are evidently the best in this special case.

S.

THE STEAM CARRIAGE SYSTEM.

From "Engineering."

So much has been said and, we may add, so much has been written, at various times during the past twenty years respecting the system of working railways by steam carriages, that the subject is apt to be regarded as somewhat a threadbare one. To a certain extent it may no doubt justly be so regarded; but, we think, to a certain extent only; and we believe that the steam carriage system is yet destined to receive far more attention from railway engineers than has hitherto been vouch-safed to it. And there are several reasons why this should be the case. In the first place there can be no doubt that, in the passenger-carrying stock of the present day, the amount of dead weight bears far too great a proportion to the paying load carried; and, secondly, railway proprietors have become cognizant of this fact, and not being rendered complacent by the receipt of enormous dividends are disposed to listen fairly to the arguments of those who advocate reasonable improvements in railway work-

ing. There are moreover, other reasons besides these—as we shall point out presently—why the steam carriage system is likely to receive a more extended trial than it has yet had.

The opponents of the steam carriage system state, as one of their strongest arguments against it, that it was tried twenty years ago and failed—or at least if it did not fail utterly, that it was abandoned because it was found that it did not satisfy the requirements of railway working. That the steam carriage system *was* tried and abandoned is undeniable; but it is well worth while to inquire more closely into the reasons for its abandonment, and see whether they would apply in the present day. It is acknowledged even by the opponents of the system—or at all events by all those whose opinion is of any great value—that the running expenses of the steam carriages formerly tried were low, that the carriages did not lack adhesion or tractive power, and that they ran steadily at high speeds; and it is therefore not to a want of these qualifications that we are to look as a reason for their disuse. Twenty years is a very long period in the history of railways, and very many important changes have taken place since Mr. William Bridges Adams's steam carriage "Fairfield" was set to work on a branch of the Bristol and Exeter Railway, and Mr. Samuel ran the "Enfield" on the Great Eastern—then the Eastern Counties,—line. At that time the average weights of locomotives and carriages were only about two-thirds what they are now, and the proportional reduction of dead weight effected by the steam carriage system was consequently far less than it would be at the present day. The early steam carriages, also, although reflecting great credit on their designers, had one very important practical defect, this being, that the engine proper and the part affording accommodation for passengers formed a single indivisible vehicle, and, as a necessary consequence, the carriage was exposed to the dirt and smoke generally to be found in an engine shed. The early steam carriages were also wanting in flexibility, as, although they were fitted with a contrivance of Mr. Adams's for allowing a certain amount of lateral motion to one of the axles, yet they were not adapted for traversing sharp curves, and their length was necessarily limited. In recent designs, such as that of Mr. Fairlie, lately illustrated in our pages, both these defects have been remedied; such a system of construction being adopted that the passenger carrying portion may be readily detached from that furnishing the motive power, and may thus be housed separately, whilst the double bogie system gives perfect facility for traversing curves.

Again, the whole essence of steam carriage construction lies in effecting every possible saving of dead weight; and there are now opportunities of effecting such saving which either did not exist or were not recognised twenty years ago. The use of steel, for instance, as a constructive material, has only become common, or, indeed, possible, during the last few years; and our steam fire-engines and the launch engines made by our leading firms of marine engineers show its usefulness in light engine construction. It is in fact by the employment of steel for boilers, connecting and piston-rods, pistons, axles, tyres, frames, and other details, that the principal reduction in the weight of steam carriages is likely to be effected. The saving of weight in each detail may doubtless be small, but the aggregate of such savings becomes something considerable. Then, again, it is not so very long since such pressures as 140 lb. or even 160 lb. per square inch now carried in many locomotive boilers were unknown in railway practice; and, as a necessary consequence, no advantage was taken in the earlier steam carriages of the reduction in weight of boilers and cylinders, which the adoption of such pressures renders possible.

So far we have only spoken of what we may term the constructive advantages likely to be possessed by the staem carriages of the present day over those of twenty years ago; but we must now regard the question of their introduction from an entirely different point of view. At the time when steam carriages were experimented upon, our railway system, as a whole, differed materially from that which we possess now, and still more materially from that which we are likely to possess before many years have elapsed. Twenty years ago the construction of a railway was looked upon as an important work, nowadays railways may almost be said to be manufactured, and the opening of a new line, unless it be one of exceptional importance, receives little more attention than the completion of a new street or roadway. Twenty years ago, when the total mileage of the railways of the United Kingdom was only about one-third of the present amount, branch lines formed a comparatively unim-

portant part of the general system, and light surface lines, serving small country towns and villages, were unheard of. At the present time, on the contrary, we have branch lines innumerable, and the question of how best to work branch line traffic has become one of the most important problems with which railway men have to deal; whilst before many years have elapsed the necessities of the country will demand the addition to our present system of hundreds of miles of light railways following as closely as possible the surface of the country traversed by them, or in many instances constructed along roads already existing—railways which it will be impossible to work economically with the engines and carriages at present in use, and which will, therefore, have to have special passenger-carrying stock designed for them.

Now, it appears to us that in the numerous branch lines of the present day, and the probably still more numerous light surface lines and tramways of the future, there is an immense field for the employment of steam carriages, which had practically no existence when those carriages were tried twenty years ago; while even on our main lines there are, as we have on previous occasions pointed out in this journal, certain circumstances under their use which would be advantageous. We believe that the advantages of steam carriages would be more universally recognised if they were not so very generally regarded as something entirely distinct from ordinary rolling stock. A steam carriage is in reality nothing more nor less than a very light train and very light engine combined, and it should be regarded as a combination of this kind, and nothing else. But, it may be said, why not employ, in place of a steam carriage, a light carriage or carriages, of the ordinary form, drawn by an engine, also of the ordinary pattern, but of light construction? At first sight it may appear that such light rolling stock would possess all the advantages of steam carriages, and obviate some of their disadvantages; and, theoretically, this is, no doubt, the case. Practically, however, the construction of very light locomotives of the ordinary pattern involves many difficulties, and we do not hesitate to affirm that no independent locomotive, capable of drawing loads of, say, 30 tons or so over lines having moderate gradients, and capable also of being run steadily at speeds of 30 or 40 miles per hour, could be constructed with such a small amount of dead weight as an engine forming part of a well-designed steam carriage. With an independent locomotive, also, the weight available for adhesion is limited to that of the engine itself; with the steam carriage the adhesion weight can be increased by imposing upon the wheels a portion of the load drawn—an important difference.

Taking, then, all the bearings of the question into consideration, it appears to us, first, that steam carriages may now be constructed which will fulfill the requirements of the traffic for which they are intended far more perfectly than those formerly tried; and, secondly, that there is at present a vast field for the employment of such carriages, both here and abroad, which did not formerly exist. Such a steam carriage, for instance, as that of Mr. Fairlie,* would work the passenger traffic on any of the Welsh lines at what, we believe, would be found to be but a small portion of the cost involved under the system at present adopted. This being the case we are glad to find that a company has been formed—under the title of the Railway Working Association—to bring, amongst other matters, steam carriages fairly before the railway public. The company which consists of but a few members, includes several engineers well known for their experience in railway making and working, as well as other engineers of acknowledged standing in their profession; and it has purchased the whole of Mr. Fairlie's patents with a view to the introduction, both here and abroad, of rolling stock constructed on that gentleman's plans, and particularly of his steam-carriage system, of which we have lately had occasion to speak in very favorable terms. It is proposed by the company to, in the first instance, place these carriages on one or more of our English lines, and maintain them for a certain percentage of the receipts, so that their capabilities may be fairly and publicly tested. At first we believe that it is intended to employ the steam carriages for branch traffic, but subsequently the system may probably be extended. The company also propose to lease and work railways, and tramways, and let locomotives and rolling stock, and we do not doubt that they will find full scope for their operations.

NEW METHOD OF STEAM GENERATION.—Some notable results have lately been obtained by means of the circulation of a stream of mercury in a coil of pipe. The lower end of the coil receives the heat, while the upper end distributes it to the water.

* See Van Nostrand's Magazine, No. 5, page 401.

THE MEASURE OF POWER AND FORCE.

Professor Henry F. Walling of La Fayette College, in referring to an article on this subject published in the "Chemical News."* asserts that the expressions MV and MV^2 are both proper, but independent measures of force; and discusses the subject as follows:—

We may avoid all confusion in this matter by adopting the modern expedient of giving different names to the same agent, in considering the different effects which it causes. If we define force to be that which, when associated with matter, causes it to move, the appropriate measure of quantity of force is "quantity of motion" or *momentum*, represented by *MV;* but when we consider the *work* which is performed, or to be performed, we find it convenient to use a unit of measurement entirely different in its nature from that of quantity of force or motion; and when measured by this unit, we term the acting cause "*power*" or "*energy*." The performance of work may be generally defined as the moving of bodies, or parts of bodies, through certain definite *spaces*, against continuous "resistances," or opposing forces. It may be represented in the form of an equation, thus—$P = ps$, proportional to MV^2, in which P represents the quantity of power or energy; *p*, the continuous pressure, or its equal, the resistance; and *s*, the distance passed through.

If any doubt should arise as to which measure is the proper one to make use of, we have only to ask ourselves what kind of effects are to be taken into consideration. In all the operations in which muscular power or motive power of any kind, acting through machinery, is concerned, *space effects* are what we have to do with—that is, we have to estimate the spaces through which matter is moved against opposing force; and *ps*, or its equivalent, MV^2, becomes the convenient and proper measure. On the other hand, when we consider the effect of a uniformly acting force like terrestrial gravity (within narrow limits), in giving motion to a body freely acted upon, we see that the force which becomes associated will be directly as the time—that is, equal increments of force will be added in equal times; and since we find that equal increments of velocity are also added, we have $F = ft$, proportional to MV: F representing the entire associated force; *f*, the force developed in a unit of time; and *t*, the time.

In applying these principles to any "question in mechanics"—that of the railway-train, for instance—it is only necessary to state the question clearly, and its answer is easily given. There are circumstances attending the motion of the train which tend to complicate the solution of the problem, namely, the resistance of the air, friction, etc. Frictional resistance is a consequence of motion imparted to molecules, by which their heat is augmented; the resistance of the air is simply due to its inertia, and thus a large part of the power of the locomotive is consumed in space effects upon the air, and the atoms or molecules of the rails, wheels, axles, etc. Having no exact means of determining the aggregate amount of these motions, we can only ascertain it by actual experiment.

We may, however, simplify the question by supposing the rails to have just sufficient inclination downwards in all parts of the train's progress to exactly balance the external resistances above mentioned. If, now, you would know the *moving force* required to give the train a certain velocity, it is clearly measured by MV, as shown in the previous editorial article; but if you wish to estimate the *work done* in giving it this velocity, or the work the moving train is capable of doing, if rendered independent of the locomotive, as the distance on a level, or up an inclined plane, it will move against a constant resistance, this quantity must be measured in units of its own kind—that is, of *ps*, proportional to MV^2.

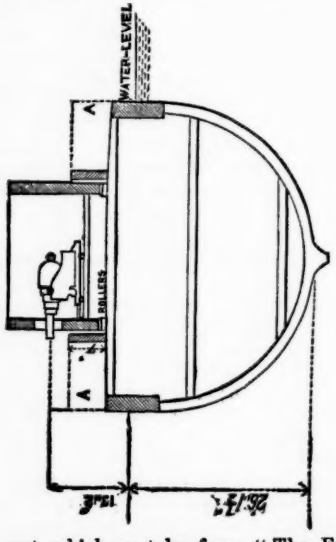
In estimating the amount of coal which must be consumed to perform a certain amount of work, we may suppose that the effect is due to the *falling together* of the atoms of carbon and oxygen, increasing the molecular motion or heat of the compound atoms of carbonic acid thus formed. This motion is transferred to the aqueous molecules, converting them into steam; the molecular motion of the steam imparts motion to the piston of the locomotive, and, finally, to the train itself. The sum of all the atomic weights, or rather attractions, multiplied by the distance through which the atoms have fallen, is the amount of work which they are capable of doing.—Hence the power thus generated is measured in units of *ps*, and is in direct proportion to the quantity of coal consumed.

We perceive, to sum up, that while MV

*See Van Nostrand's Magazine, No. 3, Page 275.

is the true measure of pure *force*, as an abstract quantity, *ps* or MV^2 is the proper measure for *power* to perform all mechanical operations.

THE NEW ENGLISH TURRET SHIPS.—The House of Commons has recently decided, by a majority of seventy-six votes, that England wants three new men-of-war; and that the best form which these men-of-war could assume was that of turret ships, each 4,400 tons burden, 285 ft. long, drawing 25 ft. 9 in. forward, and 26 ft. 6 in. aft, propelled by twin screw engines, nominally of 800 horse power, and carrying 1,750 tons of coal, assumed to be sufficient for ten days' consumption at twelve and a half knots—the maximum speed to be attained—eighteen days' consumption at ten knots, and twenty-five to thirty days' consumption "at a low rate of speed," a slightly indefinite parliamentary phrase. The ships are to have no masts, and will each carry two turrets, and two twenty-five ton guns mounted in each turret. The freeboard of these vessels is to be 4½ ft. only. The bases of the turrets are to be protected by a heavily armored breastwork, 7 ft. high. The guns will be raised above the water 13 ft. 2 in., and will fire over the breastwork.



The cut, which we take from "The Engineer," is rather a sketch than a working drawing, but shows the general design. These vessels are criticized by some authorities, and approved by others. They will undoubtedly prove useful and efficient, especially in the steam engineering department, and their adoption shows the growing appreciation not only of the turret, but of the Ericsson system.

ON THE CENTRIFUGAL FORCE OF ROTATING SHAFTS.

By W. J. Macquorn Rankine, C.E., LL.D., F.R.S.

From "The Engineer."

1. *Object of this Communication.*—The object of this communication is to explain in a form suitable for practical application, the results of a mathematical investigation of the action of the centrifugal force in long lines of shafting; an action of which no similar investigation has, to my knowledge, been hitherto published; although it is one which may seriously affect the strength, durability, and economical working of machinery.

2. *Centrifugal whirling described generally.*—In Fig. 1, let A and B represent bearings at the two ends of a rotating shaft, and A B its axis of rotation. Any small deflection of the center line of the shaft from the axis A B gives rise on the one hand to centrifugal force, tending to make the deflection become greater, and on the other hand to an elastic stress, resisting the deflection, and tending to straighten the center line again. The resistance to deflection may be shortly called the *stiffness*. For very small deflections, the centrifugal force and the stiffness both increase according to the same law, being both sensibly proportional to the deflection simply; hence whichever of them is the greater for an indefinitely small deflection, continues to be the greater until some deflection is reached which causes a sufficient difference between their laws of variation. The consequence is, that if for an indefinitely small deflection the centrifugal force is equal to or greater than the stiffness, the shaft must go on permanently whirling round in a bent form, as shown by the curves A D B, A *d* B, to the injury of itself and of the adjoining machinery and framing: a kind of motion which may be called *centrifugal whirling*. On the other hand, if for an indefinitely small deflection the stiffness is greater than the centrifugal force, centrifugal whirling is impossible.

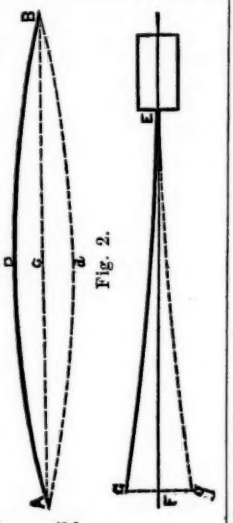


Fig. 2 represents by the curves E G, E g, the centrifugal whirling of an overhanging end of a shaft, the direction of whose axis of rotation E F is fixed by the bearing at E.

For a shaft of a given length, diameter, and material, there is a limit of speed, and for a shaft of a given diameter and material, turning at a given speed, there is a limit of length, below which centrifugal whirling is impossible.

3. *General Nature of the Investigation.*—The mathematical expression of the conditions of the problem leads to a linear differential equation of the fourth order, integrable by means of circular and exponential functions. The integrals are (as might have been expected) identical in form with those obtained by Poisson in his investigation of the transverse vibrations of elastic rods (*Traité de Mécanique*," vol. ii., § 528); and some of the numerical results calculated by Poisson are applicable to the present problem. The relation between the limits of length and of speed depends on the way in which the shaft is supported. The only two cases which will here be given are those represented in Figs. 1 and 2, viz., the shaft supported on two bearings at its ends, and the overhanging shaft with one end fixed in direction. The general equations, however, enable the problem to be solved for an indefinite number of different ways of supporting the shaft.

4. *Formulæ.*—Let g denote gravity (= 32.2 ft., or 9.81 meters per second); H, the modulus of elasticity of the material, expressed in *units of height of itself* (say about 8,000,000 ft., or 2,400,000 meters for wrought iron); r, the square of the radius of gyration of the cross section of the shaft about its neutral axis ($=\frac{\text{diameter}}{4}$ for a cylindrical shaft; $\frac{\text{diameter}}{\sqrt{12}}$ for a square shaft, etc.) and a, the angular velocity of rotation ($=2\pi \times$ number of turns per second). Calculate a certain length, b, as follows:

$$b=\left(\frac{\mathrm{H}\,g\,r^2}{a^2}\right)^{\frac{1}{4}} \quad . \quad . \quad . \quad (1)$$

Then the limit of length, l, below which centrifugal whirling is impossible, bears a ratio to b, depending on the manner in which the shaft is supported, for example:

Shaft supported at the ends,

$$\left.\begin{aligned} l &= \pi b; \\ &= 3.1416\,b \end{aligned}\right\} \quad (2)$$

Shaft overhanging; direction of one end fixed,

$$\left.\begin{aligned} l &= 0.595\,\pi\,b \\ &= 1.87\,b \end{aligned}\right\} \quad (3)$$

In practical calculations it may be convenient to put instead of $\frac{g}{a^2}$, $\frac{\mathrm{A}}{n^2}$; where n is the number of revolutions per second, and $\mathrm{A}=\frac{g}{4\,\pi^2}$ (= 0.815 ft., or 0.248 meter, nearly) is the altitude of a revolving pendulum which makes one revolution in a second. This gives for the value of b,

$$b=\left(\frac{\mathrm{H\,A}\,r^2}{n^2}\right)^{\frac{1}{4}} \quad . \quad . \quad . \quad (4)$$

It is obvious that r should be expressed in the same units of measure with H and A; for example, in feet, if they are expressed in feet.

The inverse formulæ, for the limit of speed below which centrifugal whirling is impossible in a shaft of a given length, l, are of course as follows: Make $b = 0.3183\,l$ for a shaft supported at the two ends . . (5) or $b = 0.5347\,l$ for an overhanging shaft, (6) then the limit of speed, in revolutions per second is

$$n=\frac{r\sqrt{\mathrm{HA}}}{b^2} \quad . \quad . \quad . \quad . \quad (7)$$

The following are approximate values of H A, and its square root and fourth root, for British and French measures:

	HA	$\sqrt{\text{HA}}$	$(\text{HA})^{\frac{1}{4}}$
Feet, . .	6,520,000	25,500	160
Meters, .	595,000	7,700	88

5. *Shaft with additional Load.*—An additional mass turning along with the shaft, such as a pulley, has little effect on the centrifugal force when it is in the usual position—that is, close to or near to a bearing.

The effect of an additional rotating load distributed uniformly along the shaft may be allowed for by diminishing the height, H, of the modulus of elasticity in the same

proportion in which the weight of the shaft itself is less than the gross load.

The effect of an additional rotating load at a point not near a bearing has not yet been investigated. The problem is capable of solution by means of the general integrals already known; but it is not of much practical importance; for when a shaft is so long and so rapid in its rotation as to require precautions against centrifugal whirling, the first precaution is to avoid loading it with rotating masses which are not very near the bearings.

GLASGOW UNIVERSITY, *April* 2, 1869.

CONSERVATIVE ENGINEERING.

From "The Engineer."

Some twelve months since a pair of very handsome Corliss engines were put to work at Woolwich Arsenal. These engines have 26 in. cylinders or thereabouts, and are got up in a style which leaves nothing to be desired. They may be taken as types of the most advanced practice of the day and as such we speak of them here. From records carefully kept it appears that their average consumption of very good coal is a little over 3 lb. per indicated horse-power per hour. We think most employers of steam machinery will agree with us that this is a most excellent performance, very few stationary engines of moderate dimensions in our manufacturing districts burning less than 3.5 lb. or 4 lb. of coal per horse-power per hour. As far back as 1850 it was calculated that in the cotton factories of Lancashire the average consumption of coal was between 6 lb. and 7 lb. per indicated horse-power per hour, consequently, at first sight, the Woolwich Corliss engine, taken as a type, shows that very great improvements have been made in steam engines during the last twenty years or so. At the risk of astonishing our readers we venture to assert that the improvement exists more in imagination than in reality. In other words, steam engines are now, with certain exceptions, as regards the consumption of fuel, very much what they were in the day of James Watt, who was not quite such a fool as some modern engineers would have us believe. It would not be difficult to adduce hundreds of cases to prove our proposition; one will perhaps suffice. Not long since we indicated a small factory engine constructed by Boulton and Watt, and started in 1811. Our diagrams showed that this engine was working to about one half more than its nominal power. Its consumption of indifferent slack was little more than 4½ lb. per horse-power per hour. For repairs during the sixty years the engine has been at work, almost without intermission, it has cost little or nothing, and it is at this moment in excellent condition. Here, then, we have evidence, allowing for the difference between coal and slack, going to show that the most improved engines of the present day are really but 1 lb. of coal per horse-power per hour better than those built half a century since. As to durability, when a steam engine of what is now the modern type has lasted half a century and is still in good condition, we shall be happy, if still living, to admit that work done in 1869 was at least as good on the whole as that of our forefathers.

It is the custom with too many feeble-minded engineers to run down and depreciate the works of the mighty heads and hands that have gone before them. The custom is objectionable, and to be deprecated by every right-thinking man. We have quoted the case of the Corliss engine of 1868 *versus* the Watt engine of 1811 to show that, as regards factory engines, at all events, there is no foundation for the assumption that the modern engineer has beaten, and always can beat, his predecessors by an immense distance; and nothing would be easier than to cite hundreds of other examples, selected from both the civil and mechanical branches of the profession, all demonstrating the great truth that the men who have passed away from among us, not only originated great inventions, but developed them, and gave them to us so far perfected that we find it no easy task to improve upon them. He must be a clever man who can beat James Watt, or George Stephenson, or Isambard Brunel on what they made especially their own ground; and nothing is, we think, more unjustifiable than the assertion, but too often made, that these men and their work will not bear favorable comparison with the engineers of the present day, and the deeds of the last dozen years. We have no doubt whatever that the assertion is based on honest convictions—if any conviction can be regarded as honest, the reasons for which have not been thoroughly sifted by those who hold to them. But this fact has not sufficed to save many clever men from commercial shipwreck, or to elevate others from the great mass of snobs—Thackeray used the word, so we need not apologise for it—Radicals in mechanical

science, the first held that all that had gone before their time must be susceptible of improvement; and disdaining to believe that engineers of sense and skill had ever lived till they were born, they launched out into extravagance, and, enamoured of change they adopted it for its own sake. For a time such men dazzle the world, and then they simply go out, and their place knows them no more. A little more conservatism of spirit, a little perception of the great truth that to change for the sake of changing is a mistake, a little more faith in the mental powers of the engineers who have passed away leaving their works behind them as everlasting testimonies to their skill, would have enabled many a modern engineer to win honor and gold, instead of that disappointment and penury which he has brought on himself by a reckless neglect of the teaching of the past.

Let it not be thought that this article is written without a special purpose, or that it is based on theoretical considerations. We write it with the special object of warning the rising generation of engineers against a fatal error which young men are but too willing to fall into. This error consists simply in holding that little or nothing is to be learned from the works of the last generation. Most young mechanical engineers determine that the moment they get a chance they will originate something great, or produce something in steam or general machinery which shall surprise the world. No greater blunder could be committed. If the young engineer has talents, he will find in the works of the past generation much to admire, something to avoid, and a great deal to imitate. If he lacks talent, his only chance of success is to adhere to the beaten track of precedent. In either case it is well to bear two facts in mind. The first is, that there is no more certain road to success than the power of utilising the experience of others; and the second, that innovating on established practice, is one thing, while making money is quite another.

We do not wish to be misunderstood. While advocating a conservative policy in engineering, we have no wish to stifle invention, or to bar progress by so much as a spider's thread. There is still enormous room for improvement in numberless departments of engineering, and we wish God speed to every one who endeavors to effect it. What we deprecate here is not the true spirit of improvement, but the false light, which, taking its rise in ignorance and vanity, leads men to commit great blunders, and to ensnare an innocent public in the net of destruction, yclept a limited company. Those who honestly determine that they will improve on what has already been done in any special branch of the profession, must begin by learning thoroughly what has been done, what remains to be done, and what those who have done part, have thought, and said, and written upon the subject as a whole. No true progress can be made in engineering science by him who treats the works of a past generation with contempt simply because they are old; and as years and experience come to men they will begin to perceive the truth of arguments which our younger readers may feel just a little disposed to pooh pooh. Facts crop up, indeed, every now and then in a curious and unexpected kind of way, as, for example, that which we cited in the first paragraph of this article, which should suffice to convince the most sceptical that at least sixty years ago engineers might be found in England quite as clever as any who have been born since; and the circumstance conveys a very important lesson, by which certain modern engineers would do well to profit.

CALCINATION OF IRON ORES.

From "Engineering."

Some months ago we drew attention to the ovens designed by Mr. Aitkin for this purpose, and gave a general description of their objects and construction.* Since that time we have received an account of the results obtained by the use of these ovens for roasting corbonaceous iron ores, such as blackband, and those results appear to justify very fully the opinion we formerly expressed as to the value of Mr. Aitkin's method.

The trials were commenced at the Almond Iron-works in Scotland early in 1868. Previously to that time the average make of the furnace had been from 515 tons to 720 tons per month, and the consumption of materials per ton of pig iron made had been on the average:

Coke.	Iron Ore.	Lime.
cwt.	cwt.	cwt.
27 1/10	38	10

Actually the fuel used consisted of about one-third coke with two-thirds raw coal, and the corresponding proportion of coke has

* See "Engineering," vol. vi., pp. 501 and 552.

been calculated on the basis that 1 ton of coke equals 2 tons of raw coal.

Since the commencement of the trials this furnace has been worked with coked ironstone in the proportion of about 40 per cent., and about 60 per cent. of a mixture of one-sixth of a poor lean blackband, put in calcined, and of five-sixths clay iron ore, very difficult to reduce in the furnace, and sometimes containing as much as 20 per cent. of silica after calcination.

The coked ironstone has been analysed by Dr. Penny, who reports it to have the following composition, viz. :

	Per cent.		
Metallic iron	16.23	= iron	16.23
Protoxide of iron	36.29	= ,,	28.06
Peroxide	trace.		
Sulphide	2.09		1.33
Lime	1.07		
Magnesia	2.50		45.62
Phosphates, &c.	3.63		
Silica and clay	8.00		
Fixed carbon	27.20		
Water	2.60		
	99.61		

By the analysis of Staffordshire blackband similarly treated, the amount of iron in the metallic state was 36.48 ; that of protoxide, 33.66 per cent. The slag obtained in working the furnace with calcined ore was found to be very free from metallic iron.

During the eleven months that calcined ore has been used, the make of the furnace has been on the average, 600 tons per month, ranging from 567 to 741 tons. The consumption of coke per ton of pig iron made has varied from 1 ton 8 cwt., when only 8 per cent. of the coked ironstone was used, to 17½ cwt. when the proportion used amounted to 42½ per cent. Throughout this period the proportion of the coked ironstone was gradually increased from 8½ per cent. to 42½ per cent., and the tabulated quantities of fuel consumed, show that the saving of fuel was proportionate to the amount of calcined ore in the working charge. With the largest proportion of the coked ironstone, this saving amounted to 35 per cent., or 9½ cwt. of coke per ton of pig iron made, for in the place of the former average consumption with raw ironstone of 27 cwt. per ton of pig iron, the consumption with coked ironstone was only 17½ cwt. per ton of pig iron. This fact considered, together with the refractory nature of the clay ironstone amounting to more than one-half the burden, would seem to afford conclusive evidence that a very great advantage is to be gained by calcining the iron ores of a carbonaceous nature according to Mr. Aitkin's method, and that there would be a great probability of effecting a still more considerable saving of fuel in the smelting of the ore if the whole burden of the furnace were coked black-band.

The Shotts Iron Company have lately commenced working with coked ironstone. Formerly the burden of the furnace consisted of 14½ cwt. coal and 14½ cwt. calcined ironstone, and since using the coked ore it has been only 3¾ cwt. of coal to 14½ cwt of ironstone.

The amount of fixed carbon in the coked blackband above referred to is equivalent to about 5½ cwt. of coke per ton of the ore, and since that would be to a great extent burnt away by calcining the ore in open heaps, it must be regarded as so much fuel saved. Besides this, the calcination in close ovens admits of the volatilisable portion of the bituminous contents of the ore being turned to account either as fuel or otherwise. This is a further source of saving; besides this, it must be remembered that by calcining in close ovens the oxidising influence of atmospheric air is excluded, and consequently the work of reducing the ore may be in part performed in the calcining kiln, leaving so much the less to be done in the blast furnace, as is shown by the amount of metallic iron in the coked ironstones referred to above.

Any one who has seen blackband ironstone calcined in the open air calcining heaps must have been struck by the enormous amount of combustible material that is being simply got rid of in that operation, and by reference to the analyses of this ore it will be evident that the carbonaceous portion which has hitherto been almost entirely wasted, may amount to as much as three-fourths of the fuel subsequently used in the blast furnace for reducing and melting the ore. Mr. Turran* has estimated the possible saving to be effected by substituting kilns for open air calcination, as amounting in the case of Scotch blackband to as much as 10s. per ton of pig iron, and his experience at the Dowlais Works of calcination in kilns as compared with open air calcination, is decidedly in favor of the former plan, for even after allowing for the interest of outlay for kilns, the cost of labor and fuel is much less with open air heaps.

* The Iron Manufacture of Great Britain, p. 15.

Such a mode of effecting economy of fuel in a business where the gross quantity of fuel consumed is so enormous should receive the earnest attention of those concerned, and there is probably no case in which such economy and reduction of working expenses is more necessary than in iron smelting. We therefore hope Mr. Aitkin's plan of calcination may be taken up by ironmasters actively, and that we may soon be in a position to report its extensive adoption.

REVOLVING SODA FURNACE.

Translated from "Annales du Génie Civil."

M. Lamy, professor of Chemistry at the Central School of Arts and Manufactures, made, at a recent session, a communication on the subject of "revolving furnaces," as used in England for the manufacture of soda. The material so designated is the carbonate of soda, which, according to its various forms, is called "crude soda," "sal soda," or "crystalized soda." It is an article of prime necessity, being indispensable in the manufacture of glass, soda, bleaching material, and in numberless other arts. Its production is an important branch of French industry. An important accessory result is the increase in the manufacture of sulphuric acid, which is largely used in the process.

The production of artificial soda, by the way, is altogether an art of French origin, being invented by Leblanc, whose name and deeds are too little remembered in France. It is remarkable that the process employed, the apparatus, and even the proportions of the mixture, are the same as those used by the inventor, notwithstanding all the research which has been made during three quarters of a century with the design of improving them.

M. Lamy describes the manufacture by the use of sulphate of soda, chalk and charcoal, heated to a pasty fusion in a reverberatory furnace called a soda furnace. The reaction takes place at a high temperature by means of vigorous stirring, which requires the work of skilled laborers, strong and intelligent, and receiving therefore, liberal wages. Crude soda is thus produced, from which, by lixiviation and crystalization, is extracted the 30 to 35 per cent. of carbonate contained.

The French manufactories produce annually about 100,000 tons of the various salts of soda, and in England, where the production is largest, it amounts to 300,000 tons. The high price of the requisite labor has led to a vigorous search for some substitute for manual labor. Two systems have been proposed; the first, that of Mr. Pattinson, effects the mixture by means of iron agitators attached to a spindle, fixed in the center of the furnace, and receiving its motion from a steam engine. This system was speedily abandoned. A more successful attempt is the revolving furnace of Messrs. Elliot & Russell, perfected by Messrs. Stevenson & Williams, at the chemical works at South Shields near Newcastle. It consists of a large cast iron cylinder about 5 meters long (horizontally) and 3 meters diameter, lined in the interior with refractory bricks. Its interior space is not cylindrical, but is enlarged in the middle, in order to keep the materials in the center—shaped in fact like a cask. It has also, in the interior, two longitudinal ribs, situated diametrically opposite each other, in order to effect more thoroughly the mixture during the revolution. The cylinder rests upon four friction wheels, which are supported upon a massive frame. On the exterior circumference are teeth, gearing with a pinion driven by the engine at any desirable speed. The charging hole is in the middle of the circumference, and closed by a cast iron gate. The openings at the ends serve, one for the introduction of fire from an adjoining furnace, the other, for the escape of the products of combustion, which are carried off into various accessories, and utilized in the solutions, evaporation and lixiviation. The communication of fire to the cylinder is made by means of a movable flue, held by a chain, and lined with fire brick, without which, small and unforeseen derangements might cause accidents. A great amount of fire is indispensable to a sufficiently energetic action throughout the whole of the furnace. To "cook" a charge of soda, the cylinder is raised to a red heat, and turned into such a position that the charging hole corresponds to a chute, in towhich the barrows dump the materials for the charge, which consists of 1,300 kilog, of carbonate of lime, 500 kilog of coal, broken up quite small. The cylinder is then given ten revolutions per hour, or a turn in six minutes. After an hour and a quarter the lime is calcined, and there is then added to the charge 1,160 kilog of sulphate of soda, with 180 kilog of coal, and the cylinder is revolved at the same rate half an hour longer. At the end of that time the reaction commences with the fusion

of the materials, and the velocity is increased to two turns per minute. The operation terminates in about half an hour at this rate of rotation. The cylinder is stopped with the charging hole at the lowest point, and the semi-fluid soda is drawn off into vessels moving upon tram-ways underneath.

This operation lasts two hours and a quarter, and admits of six heats and a total production of 18,000 kilog of crude soda in 24 hours, which is three times the product of an ordinary good English furnace. The heat is distributed in the most uniform manner, the sulphate is more perfectly decomposed, the operation more completely protected from the access of air, the manual labor greatly diminished, and the consumption of coal reduced in the ratio of 362 kilog to 544 or about one third. It was found at the outset that the plant was very expensive and subject to frequent disarrangement. Lately, however, the patents have expired, and the details of the furnace have been perfected so that it works with all desirable regularity, and costs, in England, not more than 35,000 franes. Mr. Stevenson has mounted four of these furnaces in his establishments, and a dozen others are working elsewhere in England—notably at Widness and St. Helens. They are built by Mr. Robert Daglish at the St. Helens foundry in Lancashire.

PULLEYS WITH LEATHER COVERING.

Translated from "Polyt Centralblatt."

The sliding or slipping of belts on the pulleys is an evil experienced by almost every one whose business depends on machine power. Various means have been devised to avoid it. One of them is to strew powdered rosin or pitch on the inside of the belt. Another is to cover the pulleys with wood. A third is to give the rim of the pulley a curved surface. These means are only palliatives, and lack a thorough, steady and continued action. Rosin and pitch are soon pressed into the leather, when they not only lose their efficacy, but contribute to the rotting and destruction of the belts. A wood covering on the pulley gets polished in a short time and is then as slippery as iron. It is therefore necessary to frequently roughen its surface, by which operation the diameter of the pulley is diminished and the proportions of the transmission are altered. A convexity of the rim of the pulley is very effective to prevent the dropping off of the belt, especially when the pulley has a horizontal position; but it counteracts the slipping of the belt to but a small extent.

We therefor take pleasure in communicating to the public a mechanical contrivance, which completely prevents the sliding of belts and all the great disadvantages resulting from it. It consists in covering with leather the working-surface of the pulleys. As the friction of leather on leather is equal to five times that of leather on iron, and as leather can be roughened and be easily kept in that condition, it is evident that a sliding of the belts cannot take place on pulleys covered with leather, not even then when the belts have to transmit the very highest amount of power. We have seen such pulleys working in sugar factories, breweries, in manufactories of German silver, in paper mills, machine shops, sawing mills and in many other mechanical establishments, in all of which they have proved of eminent usefulness and great practical value. With pulleys which have to run with a great velocity, as, for instance those that have to drive blowers and saw-frames, as well as with pulleys of small diameter, which have to transmit powerful strains, the advantages of a leather covering are especially great. But besides these evident advantages that result from the avoidance of the slipping, a leather-covering on the pulley preserves the belt; in the first place because the belt does not require tightening so hard, the friction being considerably increased; and in the second place because there is no occasion for a rapid rotting of the belt. For this rapid rotting is generally caused by the fact, that under the influence of the heat produced by friction the tannic and sebacic acids contained in the leather of the belts, combine chemically with some of the iron of the pulleys, forming a hard compound in the belts, which produces what is called rottenness and frequently causes breakages. This evil is of course avoided by covering the pulleys with leather. These covered pulleys are manufactured by Mr. S. Freund, Jr., 8 Neuenburger Strasse, Berlin, (Prussia). The coverings are fixed to the pulleys by a kind of paste or glue, which hardens in a very short time and sticks so well to iron and leather, that the greatest forces can be transmitted by the pulleys without loosening the leather. The operation of covering is very simple and can be done and renewed by every intelligent workman. The mentioned

factory is prepared to send coverings and glue abroad, together with full and explicit directions showing the way to put them on. The price is 1⅔ Prussian thalers per square foot of leather, including the glue. (Berggeist.) S.

MERCHANT MARINE.

ADVANTAGES OF IRON SAILING VESSELS.

Translated from the "Revue Maritime et Coloniale."

It seems tolerably certain that iron sailing vessels are to play an important part in the future of the merchant marine. They are more substantial, more durable, and of greater carrying capacity, than wooden vessels of the same displacement. They attain also as great speed, or even greater, for they may be constructed of greater length, and their capacity increased, while maintaining the same spread of canvass, and consequently the same equipage. The length may be six times the beam, in an iron vessel, without interfering with facility of manœuvering. The damages to a metallic hull may be repaired, at least provisionally, in almost any part without interfering with its serviceability, or capacity of continuing its voyage. At sea, iron ships behave as well as wooden ones, and resist better the stress of storms.

For East India navigation, iron hulls are free from all fears of rot, which at the end of six or seven years, and sometimes earlier, attacks wooden vessels engaged in carrying fermentable cargoes, such as rice, sesame, etc. Moreover, French vessels which frequent Indian seas, being generally of small or moderate tonnage, often find it advantageous to obtain local employment there, when a return to Europe holds out no hope of profit. But it often happens that wooden vessels cannot avail themselves of these opportunties, either through fear of having to go into dock in a foreign country, or to make repairs at some far-off port, which are enormously expensive. With iron vessels these inconveniences are avoided.

At Calcutta there are always about forty or fifty iron vessels, of about 50,000 tons altogether, which always obtain preference to wooden vessels, and generally at a higher price. It is well understood by shippers at that port, that iron vessels generally deliver their cargoes in a more satisfactory condition than wooden ones. Masts and lower yards of iron and iron top-sail yards have also great advantages, both in respect of durability and staunchness. Some English vessels have also the top-masts and standing jib-booms of iron. Iron wire rigging is generally adopted in vessels making long voyages. A suitable application of paint to protect the bottom is indispensable for the preservation of plates and rivets. Great care is necessary in taking such a vessel into dock, since it will not take paint properly until it has been scraped, scoured, washed, and perfectly dried. After a passage of one hundred days from Cardiff to Calcutta, the writer's vessel had not diminished her speed at the end of the voyage.

It is desirable that the French *Veritas* adopt for iron vessels the system of classification of the English Lloyds.

SANITARY TREATMENT OF THE REFUSE OF TOWNS AND THE UTILIZATION OF SEWAGE.—Mr. Menzies lately read a paper on this subject before the Institute of Surveyors. The paper, besides dealing generally with the subject, was devoted to an exposition of the "separate system" of drainage of which Mr. Menzies is the originator. That system is, that the rainfall shall in all cases, as a principle, be entirely separated from the sewage; the rainfall being conveyed to the nearest outlet, and the sewage to the most appropriate land for utilization. The advantages claimed for the idea are many. The first anticipated is, that there will be no gullies or openings into the streets communicating with the foul drains by which effluvium can rise into the streets or courtyards; the second, that men will not require to enter into the drains to clean out the sand and grit from the roads; the third, that no over-flows of foul or sewage matter will be necessary; and the fourth and most important, that the treatment at the outlet by irrigation will be uniform, economical, and practically perfect. The fifth advantage is, that perfect and continuous removal of all sewage may be secured by a complete system of flushing, under command at all times and at all seasons; and it is worth observing that the greatest flushing will be necessary, or rather desirable, in the town in dry weather, just when the fields outside will take it best. The sixth advantage is, that when pumping is necessary, as it is in such a vast number of cases, the economy will be very great. The idea was first brought before the public by Mr. Menzies in 1865.

THE BESSEMER FLAME.

From a paper read before the Philosphical Society of Glasgow, by Thomas Rowan, F.C.S., F.R.S.S.A., Atlas Works, Glasgow.

The Bessemer process for the manufacture of steel is now among the most important of our metallurgical operations, the chemical changes being as interesting as the mechanical appliances designed for the working of the process are ingenious. On account of its comparatively recent introduction among established industries, it affords an ample field for scientific investigation; and there is no feature of the process at once so interesting and important as that of the flame which issues from the "converting vessel."

The success of a "blow" undoubtedly depends on the accuracy and completeness of many details, but, of them all, the most important is to know and catch that moment in the existence of the flame, when the carbon in the iron has yielded its last trace to the oxygen of the air.

If a charge is "overblown," that is if it be subjected to the action of the air for too long a period, or if it be "under-blown," that is if the admission of air is stopped before the proper chemical action has been completed, the steel will be found to be defective in proportion to its unskilful treatment.

The flame issuing from the converter is the index of these changes which the molten mass of metal is undergoing during the process; but the exact moment of decarburisation is often, from a variety of causes, difficult to determine.

It is for these reasans that the examination of the flame forms the point of attraction of the process, and I have thought it might not be uninteresting to describe the general appearance which this flame presents to the eye, and some experiments which my brother has made with the spectroscope, and with colored glasses, for the purpose of more readily determining that critical period or "change" in the flame which I have spoken of. The success of these latter experiments has enabled him to attain the object for which they were commenced, and he has designed an instrument, which I shall describe hereafter, by which the "change" in the flame is more easily determined.

1. THE GENERAL APPEARANCE OF THE FLAME TO THE EYE.

When the vessel is first turned up a shower of brilliant sparks is ejected owing to the force of the blast reaching first a thin layer of metal as the vessel slowly swings round to the vertical position.

From 0° to 3 or 4 minutes.

When the full head of metal is over the blast, at first for three or four minutes, there is scarcely any flame, only a current of very hot gases and very numerous sparks.

From 3 or 4 to 5 or 6 minutes.

Gradually a small pointed flame appears in the centre of the sparks, and this quickly increases in size without gaining much brilliancy for two or three minutes.

From 5 or 6 to 9 or 10 minutes.

During the next period of 4 or 5 minutes the flame is very unsteady, both in size and in position, and its oscillations are accompanied by hollow sounds as of reports or explosions in the interior of the converter.

From 9 or 10 to 11 or 12 minutes.

Streaks or flashes of brighter flame now shoot up through this comparatively nonluminous flame, and within 1 or 2 minutes give place to a continuous stream of dense and brilliant fire which rushes far up the chimney and illuminates the entire building, often casting the shadows of the cranes, etc., against the windows through which the sun is shining.

From 11 or 12 to 15 or 16 minutes.

This flame gradually becomes thinner and more transparent without losing any of its brilliancy during the 6 or 7 minutes of the "blow," which generally remains, until it suddenly (preceded, however, by a few hollow and peculiar sounds from the interior of the vessel), loses its brilliancy and much of its size, and drops down within about half a minute to about the size it had reached at about 5 minutes of the blow, this flame, however, being both more dense and more luminous than the flame at that earlier period.

Any of the stages described may, from a variety of causes, be prolonged; or an insufficiency of blast, howsoever caused, may lengthen the entire period of the "blow" for several minutes, but the above is a fair average "blow" with the best English hematite pig iron. If inferior irons are used the flame at the change is more or less enveloped in a dense white smoke, and the change is accompanied by violent pulsations or "coughing" of the entire flame, which, under these circumstances, has often a yellowish red color to the eye, all this making the change often very difficult, if not impossible, to detect.

Nervousness or biliousness, by variously

affecting the sight of the observer, may also render him unable, *with certainty*, to determine the precise moment when he ought to "turn down," and there is a marked difference in the facility of observation noticeable between a blow taking place in daylight and one at night.

2. THE APPEARANCE OF THE FLAME.

It was important, first, to note if any of the lines belonging to the Bessemer flame were to be found in the flame given off from the coke fire used to heat up the "converter." Several examinations were made; the result of these was that, besides the invariable yellow bright line, the red line and the two bright green lines next the yellow were occasionally to be seen. Owing, however, to the want of brilliancy of this flame, the spectrum which it gave was very faint, and at times almost invisible.

On first turning up the vessel, and for about four minutes thereafter, the spectroscope showed only a continuous band of light, with the colors rather hazy, and so much blended with one another as to make it impossible to mark the junction of the different fields.

In from four to six minutes flashes of the yellow line became visible (corresponding to the appearance of tongues of a bright flame shooting up in the centre of the dull red one issuing from the mouth of the "converter"), and in one or two minutes after its first appearance, this line became quite steady, and did not disappear even at the end of the "blow." Simultaneous with the steadying of the yellow line, the red, yellow, and green fields became clear and well-defined bands of bright color.

In half to a minute later a bright green line appeared near the yellow, following which, in scarcely ever more than half a minute, a red line appeared equidistant from the yellow (of course on the opposite side). These two generally became steady together (having first appeared in intermittent flashes) in about half a minute after both were visible. With the steadying of these two lines, at once a second green line (bright and about the centre of the green field) became visible, wavering a little at first. About a quarter of a minute served generally to steady it, although sometimes it was a minute and a half from the appearance of the first green line till the second green line with the red became steady. In one to two minutes a third green line nearer the blue field came into view, and in about one minute was steady.

When the red appeared with the first green line, the second and third green lines generally appeared together, but when the red appeared with the second green line, the third green was accompanied by a blue bright line near the green field. In about ten minutes after turning up the converter the flame attained its maximum size and intensity of light; when a second and third bright line became visible in the blue field; very often these were only intermittent and very faint, but with "hot metal" and a bright flame they were pretty steady and distinct and were broader than those in the yellow, green, and red fields.

Occasionally, for about two or three minutes before the close of the blow, a bright line was seen in the purple field, pretty far to the right of the spectrum. Sometimes this only flashed brightly, but on a few occasions it was clearly seen, though faint.

With a very bright flame several dark lines were seen, but for want of definiteness it was impossible to say whether they were not due to the contrast afforded by the brilliancy of the bright ones besides which they appear. A narrow, dark line was seen on each side of the red line, and a broad, dark band dividing the yellow from the green; then one between each green line, and two in the blue field between the three blue lines. But these were only seen with an exceptionally bright flame, and therefore are not of much importance.

All the bright lines visible remained steady for several minutes before the close of the blow, affording an excellent opportunity for their examination; but at the last all, with the exception of the yellow, faded in less than thirty seconds. The purple line disappeared first, whenever it happened to be visible, then the three blue lines in the inverted order of their appearance, then the third green, after which the second, then the red, and last of all the first green, when the blast was shut off.

The green and the red lines, from their distinctness, afforded the best point for a determination of the process; and these were so constant that a sure indication could always be given by any of them, if it were made the index by which to determine the period of blowing.

Very often, on adding the charge of spiegeleisen, a large and very brillant flame rushed out of the "converter" for some

minutes; and on examining it the red, yellow, three green, and a very brillant purple line were seen, but no blue line.

3. SOME EXPERIMENTS WITH COLORED GLASSES ON THE FLAME.

I shall now proceed to describe some experiments made with colored glasses on the Bessemer flame. I may mention that what led to them was my brother being compelled to get very dark spectacles to protect his eyes, which were not very strong, from the intensity of the light of the flame. The first pair made completely overcame the brilliancy of the flame without imparting any color to it; but on ordering a second pair they showed so much color as to render them useless. On appealing to the workman who had made them, he found that no note had been kept of the kinds of glasses which had been used in the first pair; and although several attempts were made to repeat them, the second pair sent was the best he could accomplish, and they had appeared colorless to sun light. The thought then occurred that as the brilliancy of the flame varies considerably during its existence, a variation in the *amount* of transmitted light might be found to affect in a proportionate degree the power of some colored glasses to absorb colors in combination with them, and that a combination of colors might be found to give, with a small quantity of transmitted light, a distinct color which could be quite absorbed when a large quantity of light was passed through the same glasses.

Another, and perhaps the most important, consideration which led to the following experiments was, that the flame itself has a varying chemical composition as the silicon, manganese, carbon, and iron becomes successively attacked, and that the *temperature* of the flame at these various stages must necessarily be altered, giving rise of course to various colors or shades of color in the flame. If therefore a combination of colored glasses could be found which would absorb the color due to the flame at a particular temperature, it seemed clear that a *change* of temperature would become immediately visible on account of an accession or diminution of color to the flame as thus observed.

It is probable, too, that some of the color possessed by the flame at its different stages is due to the various elements which are at these periods being volatilised, but the spectroscope does not throw much light on this supposition.

The first combination of colored glasses which I have noted are a ruby and emerald. It was found that these colors mentally destroyed each other.

The Bessemer flame when viewed through them appeared white, and without brilliancy.

Ultramarine blue, dark yellow. This combination gave the same effect as above.

With a combination consisting of ultramarine blue, dark yellow, ultramarine blue, and emerald, the flame appeared of an emerald color, but was dark and without brilliancy.

In the next experiments the dark yellow and one blue were replaced by a light yellow and neutral tint thus; Ultramarine blue, light yellow, nentral tint, emerald. The appearance of the flame in this case was similar in color to that afforded by the above combination, but appeared of considerable brightness.

In the next experiments the light yellow and neutral tint were replaced by a dark yellow and red respectively, thus: Ultramarine blue, dark yellow, ruby, emerald. The flame at first was dimly seen, and without color. When it reached its maximum brilliancy it still appeared white through this combination.

With these five combinations the appearance of the sun as seen through each of them was similar in character to that of the flame, but more powerful in degree.

In the subsequent experiments the combination was as follows: Ultramarine blue, dark yellow, neutral tint, ultramarine blue. The flame appeared at first of a ruby red color, increasing in size and intensity as the "blow" progressed, the edges of the flame acquiring a lighter shade of red; but the color was too strong to admit of the changes being easily determined. Sunlight, through this combination, was slightly yellow.

In the succeeding experiments one of the blue glasses was replaced by a light yellow, giving a combination of ultramarine blue, dark yellow, neutral tint, and light yellow. The flame appeared at first of a yellowish red color. As the "blow" progressed this color became whiter with flashes of redder flame occasionally through it. At the flame's maximum brilliancy the edges assumed a light red color (nearly white), while at the root and center of the flame the color was of a darker yellowish red. When the flame dropped (at the end of the "blow") it returned to a yellowish red color, somewhat similar in appearance to the effect produced at the beginning of the blow.

Sunlight appeared slightly yellow. It will be observed that this combination gave nearly the desired effect, viz, a variation of depth of color due to the differences of temperature or brilliancy of the flame at its different stages of progression.

The yellowish tint, however, always present, showed a defect in this combination, to overcome which, further trials were made. Among other devices the light yellow was omitted, and the flame was observed with ultramarine blue, dark yellow, neutral tint. The flame appeared still red, and with the yellowish tint, though in such small degree as to show that the desired result was not far off.

Sunlight appeared dim and slightly yellow.

In the concluding experiments the neutral tint was replaced by a blue glass, with the object of ascertaining whether the yellow color could be arrested by the omission of the red or the blue component of the neutral tint, thus: Ultramarine blue, dark yellow, ultramarine blue. The combination was perfectly successful, the lingering trace of yellow being removed.

I shall now describe more fully the general appearance of the flame through it.

For the first four or five minutes all is dark, the chimney is invisible; nothing but the mouth of the converter can be made out, which appears slightly red, the sparks coming from it being scarcely visible. As the blow progress the red color increases in size and luminosity, while the outline of the vessel becomes visible.

In about twelve to fifteen minutes the flame begins to lose its color, becoming violently agitated, flashes of a lighter and brighter flame shooting up occasionally.

In about fifteen minutes a purple tint becomes visible round the mouth of the vessel, the flame gradually acquiring a white color towards the edges.

When the flame has reached its maximum brilliancy, it appears bright and nearly white, with the edges purple. The red color thereafter begins to re-appear at the mouth of the vessel and centre of white flame, gradually extending until the whole flame appears of a light red color, and with the peculiar hollow sound heard in the vessel always preceding the drop.

The centre of the flame begins to acquire a deeper color; this quickly extends and deepens. Within a minute or so of the drop, the whole flame becomes crimson, and losing its brilliancy, and within half a minute it suddenly goes back to very nearly the red color it had at starting.

This combination of glasses is now in daily use in the Atlas Works, its indications being so marked and unmistakable as to render its use safe in the most inexperienced hands. This little instrument, or "chromopyrometer" as it is purposed to call it, is arranged as follows:

One of the blue glasses and the dark yellow one are fixed in a rectangular frame, carrying at its foot a hinge, to which the thin frame holding the other blue glass is attached, and at its top a spring catch to hold this smaller frame when in its shut position; and also a pin and set screw for attaching the whole instrument to the hat of the observer, so as to place it before his eyes.

The object of having the glasses thus divided is to give facility for the observation of the flame through the combination of three, while, during the pouring, two being sufficient, the third one is allowed to hang down, when it serves to protect the lips from the great heat of the ladle and liquid steel.

In conclusion, I think it is probable that by carefully noting by means of colored glasses, such as that described, the amount of light (as determined by the shade of color visible) emitted by flames of known temperature, a scale might be formed which would enable us approximately to measure the temperature, not only of the flame of the Bessemer converter, but also that of many flames which have hitherto been considered beyond the reach of our ordinary methods of measurement.

THE MANUFACTURE OF SULPHURIC ACID.

HISTORICAL NOTICE.

Translated from "Le Génie Industriel."

Thirty years ago the only available source of sulphur, for the manufacture of Sulphuric Acid, was the volcanic region, or sol fataras of Sicily. Our national industry was, therefore, in a measure, dependent upon the complaisance of foreign powers, and at the mercy of political and commercial vicissitudes. It was probably this state of affairs that prepared the way for the development of some source of this precious mineral in France. The same stimulus was felt in other countries, and gave rise, no doubt, to the strenuous efforts made to discover within

their own soil the means of release from this burdensome dependence. At length, after much research and experiment, the industral world became indebted to a Frenchman, Michel Perret, for the first success in the new path;—a name, unfortunately, too seldom remembered. The first success in obtaining sulphur from pyrites, in the form of sulphurous acid, was attained at Lyons, near which city large deposits are found. This innovation gave to the manufacture of sulphuric acid, and through it to the chemical arts generally, such an impulse that the consumption has increased tenfold within the last thirty years.

Prior to 1833 there was a prevailing impression, derived from numerous unsuccessful experiments, that the sulphurous gases derived from the burning of pyrites, were unsuitable to the production of sulphuric acid. It was generally believed that pyrites would not burn without fuel, and it was therefore roasted with a mixture of coal. The distinguished chemist, Climent Dèsormes, had proceeded in this assumption, in using cupola furnaces, in which he was able to utilize only a small part of the gases so obtained. At that time M. Michel Perret proved that sulphurous acid gas, disengaged by the combustion of pyrites, was essentially well adapted for conversion into sulphuric acid. With this view he constructed in his father's workshop some muffle furnaces, in which he burned the pyrites, without mixing the products of combustion with those of coal, the proportion of air necessary to carry on the condensation in the chambers being very carefully regulated. This surmounted the difficulty satisfactorily. The date of the first patent for fifteen years was February 2d, 1836, and it was taken out in the name of his father, who had encouraged him in his labor and studies. The young man, at that time but twenty years of age, showed himself on more than one occasion to be a profound thinker and fertile in new ideas. The success obtained by the application of this process, for several years, on a scale of some magnitude, led to further investigation into means of economizing the combustion. The use of the old furnaces was revived, but without the use of coal. M. Baptiste Perret and M. Olivier, brother and brother-in-law of the inventor, united with him in the work of improving the process, which by their united efforts has reached the stage in which it may now be seen in the factory of St. Fons, near Lyons—one of the principal establishments of the Perret firm. We may mention one of the improvements due to M. Michel Perret, viz: the apparatus for utilizing those portions of the pyrites which are reduced in the crushing process to a state of fine division, constituting a considerable portion of the whole, and which would otherwise be wasted. A small model of the furnace used, arranged so as to show a section through its axis, and giving a complete idea of its construction, is exhibited in the window of the Perret firm, and the use of the process is freely open to all who are engaged in this branch of industry. At a little distance from a layer of pyrites in lumps, burning in an ordinary box furnace, is placed a sole of large refractory bricks, six centimeters in thickness, such as are used for spreading out plate glass. Imagine now seven other similar soles, separated by intervals of six centimeters, in a mass of masonry in which the openings are so disposed that the current of air, coming from the roasted lumps, will envelop in a very circuitous manner the surface of the pyrites in the form of powder or small pellets, spread out upon each sole. Each layer of pyrites, heated by the combustion of the preceding one, burns, either by the direct admission of air into the mass, or by a kind of cementation, requiring thirty-six hours for its completion, to such a stage, that not more than four or five per cent of sulphur remains uncombined. As might be expected, the temperature increases as we approach the upper end of the series. Mr. Michel Perret thought that the number of soles might be increased beyond eight, and he therefore constructed a furnace in which the number was carried to sixteen. But as their superposition gave a great altitude to the furnace, he divided it into two series, parallel with each other, in such a manner that the gas from the eighth and upper sole was carried by a recurved flue over the surface of the lower layer in the second series. In this furnace the temperature steadily increases from the sole where the lumps are ignited to the uppermost layer, showing with what facility the air penetrates the mixture of powder and grains of pyrites, which is spread out to a depth of three centimeters in each layer. It would seem, in order that the air may circulate in the intended manner, that all possible means of access, excepting those provided, should be rigidly closed. This can be readily managed, so far as the back part of the furnace is con-

cerned, the brick forming the sole being built into the masonry. This arrangement will not suffice, though, for the front, since the charging and discharging of the mineral is made on that side through doors opening upon each sole. To obviate this difficulty an interval is left between the front of the sole and the wall, which interval at the time of charging the lower sole is filled with slack, held in place by a closed register. In charging the second sole the slack is let down and forms a "talus" upon the level below. The different levels are charged in this way, successively, from bottom to top. The furnace is charged once in thirty-six hours, and consumes 1,000 kilog. of fine pyrites. As the charging cannot be done in an instant it permits the passage of an excess of air, while it is going on, and possibly this may explain the fact, denied by some, but maintained by many, that this system of furnace requires an excess of nitrate for the amount of sulphur burned.

Altogether these improvements, and the possession of extensive deposits of cupriferous pyrites at Chessy and Saint-Bel, have given a great development to the manufacture of MM. Perret. Their establishment at Chessy, Lyons, Vienna, Avignon and Marennes, furnish nearly 100,000 kilogrammes of acid a day, beside the other products derived from them, such as soda, iron, copper, alum, ammonical salts, hydrochloric and nitric acids, soda, &c., &c. Such an impetus has been given to general industry, in consequence of the discoveries of the firm of Perret Brothers & Olivier, that even their enormous present production of acid is insufficient, and fully twice the amount of pyrites consumed by them has been delivered to French and other consumers for manufacture by this process. In renouncing the monopoly assured to them by the possession of their extensive ore beds, this firm have entered upon a path of liberality which cannot fail to advance greatly the industrial interests of the whole nation, and have set an example most worthy of imitation.

STEAM PLOWING IN FRANCE.—At the special trial of agricultural implements at Moulins, in April, the double engine tackle of Messrs. Aveling and Porter took the first prize, and the second prize was awarded to M. Achille Farjas. The next trial takes place this month at Beauvais. The French are imitating the English in these comprehensive and frequent tests.

NOBEL'S BLASTING MATERIAL.

NEW EXPERIMENTS WITH "DYNAMITE."

Reported by MAX A. WOLFSKRON.
Translated from "Oest. Zeitschrift."

Mr. Nobel's nitro-glycerine, which produces such powerful and astounding effects, has on the other hand caused so many fatal accidents, that a certain awe of its dangerous qualities has prevented it from coming into general use. It is true, there are countries, as for instance Bavaria, where for several years past nitro-glycerine has been used for blasting, without the occurrence of any mishaps; and indeed such accidents can scarcely happen unless by neglect of the necessary precautions. But it is well known that workmen when once familiar with a work that implies some danger, become very careless, and that this carelessness often causes the most fearful accidents. Besides the nitro-glycerine, like all similar compounds of nitrogen, is in itself liable to be decomposed, when the acids produced by this decomposition affect and loosen the soldering of the metallic bottles which contain the fluid nitro-glycerine, thus causing leakage and danger. It is also not impossible that under certain circumstances a spontaneous decomposition of the fluid may take place so rapidly as to produce an explosion. Therefore, whenever it is observed that nitro-glycerine is beginning to decompose, which is easily seen by the red vapors it then emits, the whole portion should be destroyed without delay.

It is not astonishing that the importation and the transport of so dangerous a material should have been prohibited in several countries, and also in Austria. But there was no well-founded reason to include in this prohibition, as it has been done, another matter, called dynamite, which does not possess the above-mentioned dangerous qualities. Dynamite consists of calcined mineral meal from the neighborhood of Lüneburg (Prussia), impregnated with 75 per cent of nitro-glycerine, and mixed with another ingredient, which prevents it from spontaneous ignition. It hardens at 45° F., at which temperature the nitro-glycerine contained in it, congeals. In this condition it cannot be exploded by ordinary means. Charges congealed in the bore-holes must be exploded by caps and cartridges having a higher temperature than 45° F. These cartridges, which also contain the caps, are small, and the workmen can easily carry them in their pockets.

Dynamite has been manufactured at Hamburg by Mr. Nobel, since 1866, and more recently also at Stockholm, in Sweden. In the latter country the dynamite is in general use in the mines and quarries. In Prussian Silesia 8,000 lb. of it are used every month. It is besides largely in use in the mines of Saarbruck, Westphalia, Nassau and Thuringia. Considerable quantities of it have been imported to England and Belgium, in 1868.

A factory of dynamite was established in San Francisco in March, 1868, which factory had already sold 100 lb. of it per day, up to July of the same year. It is used not only in the mines of California, but also in those of Mexico, and in the blasting operations of the Pacific railroad. In California also, as in several European countries, accidents were feared from this new blasting material, and no company would at first undertake its transportation. But afterwards, when various experiments, made before an assembly of representatives of all the transport companies, had proved that these fears were groundless, the dynamite was accepted on all the railroads, steamers and stage-coaches.

The following experiments, for the same purpose, were made on the 22d of March at Hütteldorf (Austria) in presence of a delegation of the Vienna Society of Engineers: A small barrel, filled with cartridges of dynamite, was thrown down from a rock over 100 ft. high and did not explode, though striking the rock repeatedly. Two cartridges were fastened to the lower surface of a heavy block of stone, and the stone was dropped from a hight of over 20 ft. on a stone bottom. The cartridges were smashed and flattened down without exploding, and the dynamite was found in a totally unaltered condition.

Several cartridges were taken out of the above-mentioned barrel; each cartridge was cut in two parts, the one of which was made to explode by the means of a quick-match and a cap; the other part was ignited, and burned off quietly, leaving a small heap of mineral meal.

The contents of a cartridge was spread over a piece of sheet-iron and heated; the nitroglycerine evaporated without explosion.

A box of sheet-iron, filled with dynamite, was thrown into the fire without producing an explosion. The above-mentioned barrel, filled with cartridges was thrown into the fire, and burned down quietly.

To show that the dynamite cannot be made to explode, except by a strong cap, it was tried to ignite a box of sheet-iron, filled with dynamite, by a quick-match without a cap; but the dynamite would not take fire.

These experiments having proved sufficiently that the dynamite is entirely void of danger, another series of experiments was made to show the powerful effects of this new blasting-material:

A cartridge was laid on a plank of maple-wood, two inches thick, and was made to explode. It struck the plank with great vehemence, making a large hole through it.

As the strange prejudice exists that the dynamite acts better downward than upward, the same experiment was repeated, the cartridge being this time attached to the lower surface of the plank. The effect was the same.

A timber, four inches by five inches thick, rammed into the ground, was torn apart by the discharge of a half-pound cartridge.

Half a pound of dynamite was made to explode on an iron plate a quarter of an inch thick. The plate became perforated and torn; a round piece was torn out of it and thrown to a considerable distance.

But the immense power of the dynamite was proved most strikingly by the following experiment;

A $\frac{7}{8}$ inch hole was bored through the whole length (13″) of a wrought-iron cylinder of 8 inches diameter. This bore-hole was filled with one-quarter of a pound of dynamite and discharged by a Markus battery. The effect was astonishing to a high degree. The cylinder was torn in two pieces. Each piece had two cracks through its entire length, and many smaller ones. The bore was enlarged throughout, in one place to $1\frac{3}{4}$ inch. diameter. The molecular structure of the pieces was totally altered.

The succeeding experiment consisted in bursting a piece of rock without any bore-hole.

Finally, four bore-holes, $1\frac{1}{2}$ inches in diameter, and 3 ft., $2\frac{1}{2}$ ft., 2 ft., and 16 inches in depth, made into the solid rock, were discharged without tamping. The first hole was loaded with 2 pounds, the second with 10 ounces, the third with 8 ounces; the fourth, which was made in the vault of the rock, with only one ounce. The first and third were discharged simultaneously by the Markus battery; after that the second hole alone by the same battery, which also on this occasion proved its excellence. The fourth bore-hole was discharged by a gutta-percha quick-match. The effect of these discharges was satisfactory, though the rock was soft and loose and consequently unfavorable for such experiments. S.

CONDENSATION IN STEAM ENGINES.

By M. E. Cousté, Government Director of Manuf.

Translated from "Annales du Génie Civil."

An important question has long troubled the wisdom of engineers in every country where steam navigation has received any development, viz, the use of steam at high pressures in marine engines. The greatest obstacle to its employment is the excessive incrustation of the boilers from the use of sea water. The English have essayed to solve the problem by the use of surface condensers, which make it practicable to supply the boilers with water, from which the incrustating matters have been eliminated. This contrivance rendered necessary an enormous area of condensing surface, resulting in practical difficulties similar to those which defeated the attempts of Watt, Hall, Cavè, Bourdon, Ericsson, and a host of other engineers. Latterly means have been found of giving to the surface condenser a superficies of more than a square meter per horse power, which has given some good results. I am convinced, however, and I shall attempt in this paper to prove that this solution, though constituting a sort of progress, is founded on a retrograde principle ; that it realizes but a portion of the advantages which may be obtained, and that those advantages cannot be obtained completely, and with certainty, except by the use of the injecting condenser.

I propose then—

(1.) To analyze the phenomena of condensation, by laying down the general, physical and mathematical theory of the condenser, which will enable us to determine the loss of motor power caused by the condensation.

(2.) To compare the two systems, viz, condensation by injection, and surface condensation, and to show that the former is greatly superior to the latter.

(3.) To determine in what respects the present injecting condenser is capable of important improvements.

(4.) To prove that the surface condenser is subject to perturbations, which diminish, and may even counterbalance, the advantages of high pressure.

I shall further show that the injecting condenser may be made applicable to high pressure marine engines, as well as to other steam motors, by an important modification, which I shall point out, in the functions of the condenser, and I shall describe the practical means of effecting its application.

(1.) There are two kinds of condensers. In the first the steam is brought directly in contact with the cold condensing water, which mingles inseparably with the condensed water. In the second the condensing water acts upon the steam through an intervening metal, which is a good conductor of heat, and also serves the important purpose of keeping the condensing and condensed waters separate. The former is called the injecting condenser, and is the kind most frequently employed. The latter is called the surface or Hall condenser, and until quite recently had been employed only in certain special engines (ether, chloroform, alcohol engines), which are not yet out of the domain of experiment.

(2.) I shall first proceed to determine a general formula expressing the resistance of the condenser. The act of condensation is not accomplished instantly, but requires a certain length of time. If L represent the stroke of the piston, n L will be that part traversed by the piston while the condensation is in progress. Let

T m be the motor power, or work developed by the steam at each stroke.

T c i be the resistance of the injecting condenser.

T c s be the corresponding resistance of the surface condenser.

T c be the corresponding resistance of a condenser of either system (the general expression of resistance).

T a be the resistance of the air pump.

S be the area of piston of cylinder (in sq. centimeters).

L be the stroke in meters.

E be the part of the stroke during which the steam enters with a full pressure.

P be the pressure (in kil. per sq. cent.) after expansion, and at the instant of opening communication with the condenser.

H be the pressure before expansion.

p be the normal pressure in the condenser; *i. e.*, the pressure which remains after the condensation is finished (in kilog. per sq. centimeter).

n L be the fraction of the stroke during which the condensation is in progress.

r be the ratio of the capacity v of the condenser (including its connections) to the capacity V of the cylinder (including the volume occupied by the piston and the clearance spaces, thus,

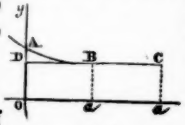
$$r = \frac{\text{condenser}}{\text{cylinder}} = \frac{v}{V}.$$

As soon as the communication is opened

between the cylinder and condenser, the pressure P, corresponding to the volume V, becomes $\frac{P\,V}{V+v}$. At the same instant the pressure p, which corresponds to the volume v, becomes $\frac{p\,v}{V+v}$. At that instant therefore the pressure in the condenser is $\frac{P\,V+p\,v}{V+v}$, or $\frac{P+p\,r}{1+r}$. During the part of the stroke n L this pressure diminishes (at a rate corresponding to the condensation), passing from $\frac{P+p\,r}{1+r}$ to p; and during the part $(1-n)$ L it remains equal to p. Let us represent the successive values of this pressure by the ordinates to a curve. Let $x''=$ O $a'=$ L, $x'=$ O $a=n$ L, $a\,a'=(1-n)$ L

$$y\,o=\text{O A}=\frac{P+P\,r}{1+r}.$$

$y'=a$ B $=a'$ C $=p$.



The portion B C of the line will be straight and parallel to the axis of x; the portion A B will be curved and tangent to B C at the point B.

T c will be represented by the surface S of the piston multiplied by the area A O a' C. The area of D O a' C $=$ L p. To express the other part of the area, we must know the curve A B. In this particular case we may determine it approximately by the Watt indicator, and in this general analysis we shall replace it by an approximation sufficiently accurate, if we use the arc of a parabola, having its vertex at B, passing through A, and having its axis parallel to the axis of y. This arc will in general differ immaterially from the true curve. Hence the part A D B of the total area will be $\frac{1}{3}$ A D$\times$B D $=\frac{1}{3}\left(\frac{P+p\,r}{1+r}-p\right)\,n$ L $=\frac{1}{3}$ L $\frac{P-p}{1+r}n$. The total area is then $\frac{1}{3}$ L $\left(\frac{P-p}{1+r}\,n+3\,p\right)$, and the *work* of the condenser is

$$\text{T}\,c=\tfrac{1}{3}\,\text{S L}\left(\frac{P-p}{1+r}\,n+3\,p\right). \quad (1)$$

This expresses the *resisting work* of the condenser, so far as relates to the counter-pressure alone; and if we simply add the deduction due to the work T a of the air pump, we shall obtain the whole resistance of the apparatus. The formula (1) is applicable to both kinds of condensers, and we shall transform the expression further on, so as to introduce the peculiar elements of both.

(3.) First, however, it is necessary to consider the values, both arbitrary and necessary, which the quantities designated above may take.

T a is a quantity nearly constant, as applied to a given engine, varying very slightly with the quantity of water to be drawn, with the slight counter-pressure of the condenser, and the slight variations of atmospheric pressure. But when the building of an engine is contemplated, it is a matter of no small moment to design it so as to employ the minimum of water, whether the object be to economize it on account of its small supply, or to diminish the effect of T a, which depends for its value chiefly upon the area of the pumping piston.

(4.) The value of P will depend upon the initial pressure H of the steam when it enters the cylinder, and upon the rate of expansion allowed. It is an advantage to give this expansion its greatest practicable amount. L and S being constant in a given engine, the expansion will be limited by the amount of useful effect which can be produced in a given time; and as this latter quantity can be made to vary, its variation should be regulated entirely by the cut-off, which may work automatically or at control of the engineer. But we are of the opinion that, other things being equal, the range of expansion will be extended in proportion as the pressure is increased, and hence the advantage (which is considerable) of employing steam at high pressures.

(5.) The pressure in the condenser passes, as we have said, through different values during the stroke of the piston. For a given value of P, and for a single quantity of water introduced, the condensation will be effected in a time equal to, or less, or greater, than the duration of the stroke of the piston. In the first instance the pressure in the condenser will reach the *normal* value p before the end of the stroke; in the second p will be reached just at the conclusion of the stroke; in the third case the value of p must be increased to p', in order that the normal pressure may be reached during the time of the stroke. We must therefore give to p just the value which the normal pressure has at the instant the stroke is completed. It will be observed that p is the sum of two pressures—the one f due to the steam (watery vapor) which remains normally in the condenser, the other f due to the gases given off by the condensing and feed water, and to the air which may find access by leakage. In an apparatus proper-

ly managed and cared for, and built upon correct principles, there ought not to be any leakage. The gases given off by the feed waters of the boilers are insignificant in well managed engines, because that water is drawn from the condenser itself, and has already been freed from the greater part of its gases. We may then proceed to determine f and f'.

In a particular case we might determine f by means of a table of the elastic forces of vapors, and according to the normal temperature of the condenser. But we must note that this temperature is really higher than that of the water taken from it, because the contact of the condensing water and the steam is of short duration, and only partial—the water not being generally in a sufficiently divided state to establish a thermal equilibrium in so short a time. In order to determine it the thermometer should be placed in a part of the condenser opposite the entrance of the steam, and protected from the injected stream. The quantity f being thus obtained, we shall have f' by deducting $p-f$; and the value of p will be given by the manometer of the condenser.

(6.) But it will be advisable to introduce into eq. (1) the value of p as a function of the normal temperature of condensation, θ of the temperature, t of the cold water, and of the volume q of the water resulting from the condensed steam at each stroke of the piston.

We shall then have (according to Southern)—

$$f = A + \left(\frac{B+\theta}{C}\right)^{5.13}; \quad \begin{matrix} A = & 0.0034542 \\ B = & 46{,}278 \\ C = & 145.36 \end{matrix}$$

Also let

θ = the temperature of the condenser corresponding to the elastic force of the steam f.

t = the temperature of the injected cold water.

$\frac{1}{m}$ = the proportion (in volume) of gas which that water contained.

Q = the volume of cold water theoretically necessary for injection at each stroke of the piston.

q = the volume of water resulting from the condensation of the steam at each stroke.

$$\text{Then, } Q = q\,\frac{650-\theta}{\theta-t}.$$

But in the injecting condenser this quantity Q should be doubled in practice. The volume of gas introduced into the condenser at each stroke of the piston is then (at the pressure of 1 atmosphere)

$$\frac{2\,Q}{m} = \frac{2\,q}{m}\cdot\frac{650-\theta}{\theta-t},$$

at the temperature t, and at the temperature θ of the condenser is $\frac{2q}{m}\cdot\frac{650-\theta}{\theta-t}\cdot\frac{274+\theta}{274+t}$

The pressure of this gas is that of the atmosphere, 1.03 kilog. per square centimeter under the volume given above, and becomes, under the volume v of the condenser,

$$f' = \frac{2.06}{m}\cdot\frac{q}{v}\cdot\frac{650-\theta}{\theta-t}\cdot\frac{274+\theta}{274+t},$$

$$\text{Hence, } p = A + \left(\frac{B+\theta}{C}\right)^{5.13} + \frac{2.06}{m}\cdot\frac{q}{v}\cdot\frac{650-\theta}{\theta-t}\cdot\frac{274+\theta}{274+t}. \quad . \quad . \quad . \quad . \quad (2)$$

(7.) The quantity n varies in consequence of some circumstances which it is well for us to examine.

The escape of the steam from the cylinder to the condenser, though very rapid on account of the difference of the two pressures, is by no means instantaneous. The connections are always ample, of course, but the opening of the ports is, during a portion of the valve movement, partially obstructed. This becomes apparent on the diagrams by a rounding off of the angles where the piston changes its motion, and by the rapid fall of the pressure just before the instant of cut-off. But in well built injecting condensers this partial cause of retarded condensation may be neglected, especially if the velocity of the piston be not excessive. It must not, however, be neglected in surface condensers, because the condensing surfaces usually consist of tubes of small diameter, among which the steam circulates with some difficulty, especially when it encounters a certain amount of air and other permanent gases.

Secondly, the cold water is introduced in the form of jets more or less divided, offering a certain amount of surface of direct contact to the steam. Water being a poor conductor of heat, an equilibrium takes place almost at the instant of contact of the steam with the water of the jets, and that collected in the bottom of the chamber—the walls of the chamber also taking part in the operation. But all these surfaces are heated by the condensation, and their condensing power correspondingly reduced; and as they are only partially cooled again by succeeding movements, it would appear that

their action cannot be instantaneous in destroying the difference between the pressures P and p.

(8.) Let us take the general expression $x = \frac{L}{2}(1 - \cos \tilde{\omega})$ for the space passed over by the piston for any angle $\tilde{\omega}$ described by the rotation of the crank—neglecting the small variations arising from the variable position of the connecting rod. The angular velocity of the crank being constant, $\tilde{\omega} = \tilde{\omega}' \frac{\tau'}{\tau}$; or, taking for the angular unit $\tilde{\omega}' = 180°$, then $\tilde{\omega} = \frac{\tau'}{\tau}$; in which equation τ' = the time corresponding to x, and τ = the time of a whole stroke of the piston. Then

$$x' = \frac{L}{2}\left(1 - \cos \frac{\tau''}{\tau}\right)$$

τ'' being the time corresponding to x', and

$$\frac{x''}{L} = n = \tfrac{1}{2}\left(1 - \cos \frac{\tau''}{\tau}\right).$$

We assume τ' and τ to be expressed in seconds.

Let Φ express the rapidity of the absorption of heat by the condenser, *i. e.*, the quantity absorbed in one second; then $\tau'' \Phi$ will be the quantity absorbed during the whole process of condensation. The expression for this quantity is $D\, q\, (650 - \theta)$; D being the density of the water, and assuming D =1, then

$$\tau'' = \frac{q\,(650 - \theta)}{\phi}.$$

Substituting this,

$$n = \tfrac{1}{2}\left[1 - \cos \frac{q\,(650 - \theta)}{\tau\ \phi}\right]$$

Now we may put $\Phi = R\,\phi$, R being a co-efficient < 1, depending partly upon the resistance due to the pressure of air, and partly upon the friction of the steam, whether in the connections of the general condenser, or in the tubes of the surface condenser. ϕ will be composed, first, of heat transmitted through the walls or skin of the condenser, and expressed by

$$a = \kappa\, \tau\, \frac{a' - b}{e} \quad . \quad . \quad . \quad . \quad (3)$$

in which

κ = the co-efficient of conductibility of the walls; that is, the quantity of heat which passes in 1″ of time through one sq. met. of this wall, with an assumed thickness of one millimeter and for a difference of 1° of temperature between the two sides of the wall.

σ = the surface of each of these two sides.

a' = the mean temperature of the inside.

b = the mean temperature of the outside.

Second—There also enters into the value of ϕ the heat β absorbed by the water collected at the bottom of the condenser.

Third—The heat absorbed by the injected cold water.

This last quantity, by far the greatest, will be expressed by $\mu\, \Sigma\, (\Theta - t)$, in which

μ = the exterior conductibility of the water, or the quantity of heat which enters in 1″ of time into one sq. meter of aqueous surface, for a difference of 1° between the temperature of the water and of the steam.

Σ = the surface of the jet in sq. met.

Θ = the mean of the temperatures through which the condenser passes during a stroke of the piston.

t = the maximum temperature of the injected water.

We may then place as the general value of n,

$$n = \tfrac{1}{2}\left\{1 - \cos \frac{q\,(650 - \theta)}{R\,\tau\,[a + \beta + \mu\,\Sigma\,(\Theta - t)]}\right\} \quad (4)$$

(9.) For the sake of brevity let us place

$$M = \frac{2.06}{m} \cdot \frac{650 - \theta}{\theta - t} \cdot \frac{274 + \theta}{274 + t}.$$

also;

$$f = A + \left(\frac{B + \theta}{C}\right)^{5.13}$$

and substituting in eq. (1) these values, and the value of n, as given above,

$$T c = \tfrac{1}{3}\, S\, L \left[\left(P - f - M\, \frac{q}{v}\right) \tfrac{1}{2}\, \frac{1}{1 + r} \times \left(1 - \cos \frac{q\,(650 - \theta)}{R\,\tau\,[a + \beta + \mu\,\Sigma\,(\Theta - t)]}\right) + 3\left(f + M\, \frac{q}{v}\right)\right] . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

This equation is general and applicable to both kinds of condenser—cancelling the term $\mu\, \Sigma\, (\Theta - t)$ when it is applied to the surface condenser. In the injecting condenser we may also suppress a and β as being inconsiderable compared with $\mu\, \Sigma\, (\Theta - t)$. In reality the external and internal surfaces of this condenser are always incrusted or oxidized, and the latter is also always protected by a tissue of stagnant water—circumstances which diminish considerably the conducting power of the walls. It is otherwise plain that β is a very inconsiderable quantity, because the warm water in the bottom of the condenser exposes to the steam only its upper or warmer surface, while its interior conducting power is very small.

For the injecting condenser then we may place

$$T\,c\,i = \tfrac{1}{3}\,S\,L\left[\left(P - f - M\,\frac{q}{v}\right)\tfrac{1}{2}\cdot\frac{1}{1+r}\times\left(1-\cos\frac{q\,(650-\theta)}{\tau\,\mu\,\Sigma\,(\Theta-t)}\right)+3\left(f+M\,\frac{q}{v}\right)\right. \quad (6)$$

We have assumed R = 1. We shall also have occasion to equate the value of T *c i* in the forms,

$$T\,c\,i = \tfrac{1}{3}\,S\,L\left[(P-p)\,\frac{1}{1+r}\cdot\tfrac{1}{2}\left(1-\cos.\ \frac{q\,(650-\theta)}{\tau\,\mu\,\Sigma\,(\Theta-t)}\right)+3\,p\right] \quad . \quad . \quad . \quad (7)$$

$$T\,c\,i = \tfrac{1}{3}\,S\,L\left[\frac{P-p}{1+r}\,n+3\,p\right] \quad . \quad . \quad (8)$$

We will put this expression into another form, which will show more clearly the influence of the surface Σ. Let Σ′ be such a value of this surface that the duration of the condensation may equal that of a stroke of the piston, or so that $n = 1$. We shall then have in eq. (4), in which α and β are suppressed and R = 1,

$$n = \tfrac{1}{2}\left[1-\cos\frac{q\,(650-\theta)}{\tau\,\mu\,\Sigma'\,(\Theta-t)}\right] = 1$$

whence $\cos\dfrac{q\,(650-\theta)}{\tau\,\mu\,\Sigma'\,(\Theta-t)} = -1.$

in other words

$$\text{arc}\,(\cos = -1) = \frac{q\,(650-\theta)}{\tau\,\mu\,\Sigma'\,(\Theta-t)} \text{ or,}$$

$$1 = \frac{q\,(650-\theta)}{\tau\,\mu\,\Sigma'\,(\Theta-t)}. \quad . \quad . \quad (9)$$

Deducting from this equation the value of q and substituting it in eq. (7), we have

$$T\,c\,i = \tfrac{1}{3}\,S\,L\left[(P-p)\,\frac{1}{1+r}\cdot\tfrac{1}{2}\left(1-\cos\frac{\Sigma'}{\Sigma}\right)+3\,p\right]. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

It is obvious that this formula is applicable only for values of Σ greater than, or at least equal to, Σ′; for if we assume a value for Σ lower than Σ′, it would be equivalent to supposing that the condensation would take place at a normal temperature θ' higher than θ.

(10.) It may be remarked that all these expressions of work consist of two elements; one expressed by the first term, which is the work due to the retardation of the condensation, or its duration, and the other due to the normal counter-pressure. I purpose discussing these quantities separately, beginning with the counter-pressure.

(11.) In principle there is no maximum rate of injection. On the subject of normal counter-pressure there is a prevalent opinion that the volume of gases introduced increasing with the quantity of water, there is, for each kind of water and condenser, a rate of injection to which there corresponds a minimum counter-pressure. This is true, but it is the result of imperfections in condensers, and not of injecting condensation as a principle, as we shall prove.

We have taken (§ 6)

$$p = A + \frac{(B+\theta)^{5.13}}{C} + f';$$

f' being the part of the pressure due to the gases brought by the condensing water. Eq. (2) expresses the value of p in ordinary condensers, where, as we have already remarked, it is necessary to inject about twice the quantity theoretically necessary, $\left(Q = q\,\dfrac{650-\theta}{\theta-t}\right)$ on account of the imperfect mixture of the water with the steam. If we suppose the mixture to be perfect, then the equation

$$Q = q\,\frac{650-\theta}{\theta-t} \quad . \quad . \quad . \quad (2a)$$

expresses the quantity effectively injected, and the temperature, and may be used to determine either one of these quantities in terms of the other.

On this supposition, in place of eq. (2), we have

$$p = A + \left(\frac{B+\theta}{C}\right)^{5.13} + \frac{1.03}{m}\cdot\frac{q}{v}\cdot\frac{650-\theta}{\theta-t},$$

supposing the factor $\dfrac{274-\theta}{274-t} = 1$, which is approximately true in practice.

Replacing θ by its value deduced from the above

$$\theta = \frac{650 + t\,\dfrac{Q}{q}}{1+\dfrac{Q}{q}}, \quad . \quad . \quad . \quad (2b)$$

we shall have

$$p = A + \left[\frac{B}{C} + \frac{650 + t\,\dfrac{Q}{q}}{C\left(1+\dfrac{Q}{q}\right)}\right]^{5.13} + \frac{1.03}{m}\cdot\frac{Q}{v}$$

Differentiating and placing $\dfrac{dp}{dQ} = 0$,

$$\frac{dp}{dQ} = 0 = -5.13\left[\frac{B}{C} + \frac{650 + t\,\dfrac{Q}{q}}{C\left(1+\dfrac{Q}{q}\right)}\right]^{4.13} + \frac{650-t}{C\left(1+\dfrac{Q}{q}\right)^2}\cdot\frac{1}{q} + \frac{1.03}{m}\cdot\frac{1}{v} \quad . \quad (2c)$$

It is from this equation that we may deduce the value of Q which will give the minimum value of p. We shall proceed, then, to show that, within practical limits, there is no value of Q which will satisfy this equation.

1st. It is impracticable to condense beyond 100°, and it is rarely advantageous to condense below 20°, which corresponds to a tension of 1.70 centimeters of mercury, which should be at least sufficient to raise the valves of the air and water pump. According to eq. (2 b) the values of $\frac{Q}{q}$ corresponding to 100° and 20° respectively, are (supposing $t=10°$) 6.1 and 63.

2d. The value of m is hardly greater than $\frac{1}{10}$, and we will therefore take it at that value.

3d. q depends upon the pressure H of the steam before cut-off, and the quantity E, the part of the stroke during which steam is admitted. H varies between 1 and 10 atmospheres, and E between $\frac{1}{15}$ and $\frac{1}{2}$. Hence we have $q=\frac{u}{\triangle}$; (u being the volume of steam introduced, and $\triangle$ the specific volume of its resultant water at the pressure H.

For H = 1 atmos. and E = $\frac{1}{2}$ we find

$$u=\frac{V}{2} \text{ and } \triangle = 1700;$$

whence

$$q=\frac{V}{1700\times 2}$$

For H = 8 atmos. and E = $\frac{1}{15}$, we find

$$u=\frac{V}{15} \text{ and } \triangle = 254;$$

whence

$$q=\frac{V}{254\times 15}.$$

4th. The volume of the condenser v varies between $\frac{V}{5}$ and V. Introducing these values into eq. (2 c), as well as the values of B and C.

For $\theta = 100°$, or $\frac{Q}{q}=6.1$,

we find for H = 8 atmos.

$$-5.13\left[0.33+\frac{650+61}{145\times 7.1}\right]^{4.13}+\frac{640}{145\times 7.1^3}\times\frac{254\times 15}{V}+\frac{1}{V}1.03\times 20=-1714\frac{1}{V}+20.6\frac{1}{V};$$

a result with a *negative sign*.

For $\theta = 20°$ or $\frac{Q}{q}=63$,

we find for H = 8 atmos.

$$-5.13\left[0.33+\frac{650+630}{145\times 64}\right]^{4.13}\times\frac{640}{145\times 64^3}\times\frac{254\times 15}{V}\times\frac{1}{V}1.03\times 20=-171.14\frac{1}{V}+20.6\frac{1}{V},$$

a result also with a negative sign.

It is clear that the results will continue to be negative in the case where the expansion E is $\frac{1}{2}$, and *à fortiori* in any case where it is expressed by a smaller fraction between $\frac{1}{2}$ and $\frac{1}{15}$. It is also plain that the results will be negative for pressures H lower than 8 atmospheres, since, in the negative term, which alone is a function of the pressure, the factor 254 will be replaced by numbers exceeding that factor, in proportion as H diminishes. Hence the equation (2 c) admits of no roots for values of the variable corresponding to normal temperatures between 20 and 100 degrees; in other words, there is no minimum of pressure between these limits. We therefore infer that we may advantageously bring the normal temperature θ of the condenser as near to that of the cold water as the circumstances of each particular case will warrant; regard being had to the manner of disposing of the water. The vacuum has then no limit except the residuary force necessary to lift the valves of the air and water pumps. It will be readily seen, from a particular example, that with the cold water at 10° to 15° (since we can practically obtain only a vacuum indicated by 6 to 7 cent. of mercury, let $\theta=45°$), we can, by suitably increasing the rate of injection, and supposing that we can always obtain a complete mixture of water and steam—we can, I say, reduce θ to 20° or 25°, and therefore reduce P to 2.8 or 2. cent. of mercury.

I conclude, then, that that portion of the work of the injecting condenser due to the normal counter-pressure p S L can be reduced from .093 S L, corresponding to a vacuum of 7 cent. of mercury, to .027 S L corresponding to a vacuum of 2 cent., making a reduction of say 71 per cent.

(12.) In formula (7) the first term is always positive, since P is always greater than p; otherwise the piston would be stopped before the end of the stroke; or if it con-

tinued its motion by virtue of the inertia of the machinery, the living force of the latter would be diminished, so as to interfere with the regularity of the movement of the engine, and without any compensating advantage. This shows that the cut-off may be carried too far to allow of an efficient condensation. Hence, other things being equal, if we make r vary, the work $T\,c\,i$ will diminish proportionally to $(1+r)$. Again, $\cos \frac{q\,(650-\theta)}{\tau\,\mu\,\Sigma\,(\Theta-t)}$ increases from -1 to $+1$, according as τ and Σ, or either of these two, increase. It appears from eq. (17), which follows, that the term expressing the work due to the retard of the condensation is in the inverse ratios of τ^2 and Σ^2. Hence the inferences, that it is advantageous to increase as much as practicable the vacuum space of the condenser; to give the injected jet of water the largest possible surface Σ; and to increase as much as possible the length of stroke of the piston.

(13.) The first of these conditions seems to have escaped the attention of engineers and builders. The only point upon which they have been preoccupied in this particular is to increase in some measure the capacity of the condenser, with the object of diminishing the back pressure of the gases; persuaded, no doubt, that the condensation is instantaneous. But eq. (6) shows that $T\,c\,i$ varies not only by the quantity $M\,\frac{q}{v}$ relative to the pressure of the gases, but still more by the factor $(1+r)$. In fact the rule generally adopted for the capacity of the condenser, is to make it between $\frac{1}{4}$ and $\frac{1}{2}$ that of the cylinder for single acting engines, and $\frac{1}{8}$ for double acting.

M. Farcot has deviated from this rule in the engines of the Imperial manufactory of Gros-Coillon, which have a condenser equal to the cylinder in capacity. We believe we can recommend his variation. We will show the importance by an example. Take a particular case, where $P = 1$ at. $= 1.03$ k.; $p = 0.1$ at. $= .103$ k. Take formula (8), where $n = 1$. Substituting, we have

$$T\,c\,i = S\,L = \left(\frac{.309}{1+r} + .103\right)$$

Make successively $r = \frac{1}{8}$, $\frac{1}{4}$, 1, 2. Then

$$T^{(\frac{1}{8})}\,c\,i = .377\ S\ L$$

$$T^{(\frac{1}{4})}\,c\,i = .360\ S\ L$$

$$T^{(1)}\,c\,i = .257\ S\ L$$

$$T^{(2)}\,c\,i = .206\ S\ L$$

and substituting

$$\frac{T^{(\frac{1}{8})} - T^{(1)}}{T^{(\frac{1}{8})}} = \frac{120}{377} = .32.$$

$$\frac{T^{(\frac{1}{8})} - T^{(2)}}{T^{(\frac{1}{8})}} = \frac{171}{377} = .45.$$

$$\frac{T^{(\frac{1}{4})} - T^{(1)}}{(T^{(\frac{1}{4})}} = \frac{103}{360} = .28.$$

$$\frac{T^{(\frac{1}{4})} - T^{(2)}}{T^{(\frac{1}{4})}} = \frac{154}{360} = .42.$$

Hence, in an engine expanding till the pressures becomes 1 atmosphere, condensing at 0.1 at., and where the duration of the condensation equals the time of a stroke of the piston,

1st. The condenser having a vacuum capacity of $\frac{1}{8}$ the volume of the cylinder, ($r = \frac{1}{8}$), if it be replaced by another equal to the volume of the cylinder ($r = 1$), then the work $T\,c\,i$ will diminish 32 per cent. If replaced by one double the volume of the cylinder, $T\,c\,i$ will diminish 45 per cent.

2d. The condenser having $\frac{1}{4}$ the volume of the cylinder, if the same substitutions are made, $T\,c\,i$ will diminish in the first case 28 per cent, and in the second 42 per cent.

(14.) As to the second inference (No. 12), no importance has heretofore attached to it, though it possesses a great deal. The water is brought into a receiver placed beside the condenser, whence it flows into the latter by means of atmospheric pressure through a common nozzle, with no provision, however poor, for dividing the jet. It will be well to examine the influence of Σ upon the work of the condenser.

Let $P = 1.03$ k., $p = .103$ k., $r = \frac{1}{8}$, and taking eq. (10),

$$T\,c\,i = S\,L\left[.128\left(1 - \cos\frac{\Sigma'}{\Sigma}\right) + .103\right]$$

it will be seen that, if Σ be only slightly increased, $T\,c\,i$ will be only insensibly diminished. This last remark explains why we obtain no improvement in the vacuum, practically, by increasing the admission of water beyond a certain degree; for though we increase the admission of water, we increase

the surface of the jet very inconsiderably, and even this slight increase is counterbalanced, or even more, by the increase in the quantity of gases brought in. But suppose that, by means which I shall indicate, we could double, triple, quadruple, centuple Σ; the differences between the values of $T\,c\,i$ would become very perceptible. For instance, make successively $\Sigma = \Sigma'$; $10\,\Sigma'$; $100\,\Sigma$; then

$$T\,c\,i = S\,L\,[.128.2 + .103] = .359\,S\,L$$

$$T\,c\,i = .109\,S\,L$$

$$T\,c\,i = .1031\,S\,L,$$

and

$$\frac{T\,c\,i - T\,c\,i}{T\,c\,i} = \frac{.250}{.359} = .69.$$

$$\frac{T\,c\,i - T\,c\,i}{T\,c\,i} = \frac{.2559}{.359} = .71.$$

Hence, having an engine where the duration of the condensation equals the time of the stroke of the piston, where $\Sigma = \Sigma'$ or $n = 1$, if we increase tenfold the surface of the jet, the work will diminish 69 per cent, and if we increase it a hundredfold, the work will diminish 71 per cent.

(15.) Let us now inquire how the desired increase in the surface of the jet may be obtained, and within what limits it may be properly increased.

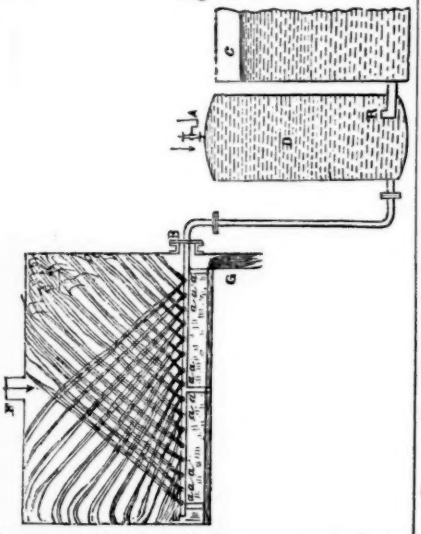
M. Sanial du Fay, a naval engineer, has devised a method of "pulverizing" the water, or reducing it to the form of spray, thus giving it a great amount of surface. This method consists in forcing the water through two converging nozzles, so that the two streams collide a short distance from the points of emergence, the result being a minute division of the water. The minuteness of the division increases with the pressure under which the water is forced. By this means a litre of water can be given 600 square meters of surface. The water enters the condenser in this comminuted condition, and the stream, mingling with it, obtains a great surface of contact—as it were, particle with particle. There results a sudden and intimate mixture, a very rapid condensation, and a perfect equilibrium of temperature between the water of the condenser (consisting of injected water, and water of condensation) and the normal vapor of the condenser.

(16.) Besides the advantage of rapid condensation, we also have the power of diminishing the actual rate of injection. Let us examine this.

1st. The quantity of water at the temperature t necessary theoretically to condense to the temperature θ is, for each stroke, $Q = q\,\frac{650 - \theta}{\theta - t}$. Generally the quantity of water required in practice varies between 1.75 Q and 2 Q. This is due to the fact that a considerable portion of the water escapes contact with the steam, and has no effect upon the condensation. Practically, on the one hand, the surface Σ of the jet is relatively small, and is but little increased by opening wider the injection valve. On the other hand, the water is kept flowing in a constant stream, while it should, on principle, diminish as the condensation goes on, and terminate with it. Hence it happens that the water issues from the condenser at a temperature below θ, and the condensation occupies the whole stroke of the piston. This is shown by the diagrams when they are drawn with care, and by the aid of an indicator sufficiently sensitive. To approximate the rate of injection to the theoretical rate there is requisite, not merely a rapid and intimate mixture of water and steam, but also an intermittent injection, lasting only during the time absolutely necessary for condensation.

With this view I propose the following arrangement. The cold water cistern, instead of being open, is to be closed and put into communication intermittently, at each stroke of the piston, with steam which surrounds the cylinder. This communication should last a little longer than the time requisite for condensation. The flow of the water will be effected by the pressure of the steam, and will cease the moment the communication is intercepted. Fig. 2 will give the idea substantially. D is the cistern, subject to intermittent pressure; A, a valve worked by the rod of the slide valve; E, injecting condenser; F, steam port opening into condenser; G, communication with air and water pump; *a*, Du Fay nozzles for comminuting the water; they are fixed in a copper pipe, which can be easily withdrawn in case of obstruction, and another replaced through the hole B; C, reservoir of cold water; R, check valve between the cistern and reservoir. When the valve A is open, the check valve R shuts; when it closes, R

Fig. 2.



is opened by atmospheric pressure, and the water expended from D is resupplied automatically by the reservoir C. By means of such an arrangement the actual rate of injection may be diminished so as not to exceed one-tenth the theoretical rate, which is, in effect, the use of water amounting to 1.1 Q in place of 1.75 Q — an economy of $\frac{.65}{1.75}$ or .37.

This economy may, in some cases, be a matter of no small consequence; indeed it may become highly important when water is in limited supply, or has to be pumped from a great depth, or when it is necessary to allow a high temperature in the condenser and consequent strong back pressure, or even to otherwise abandon the condenser altogether.

2d. In a case where this economy of water can be realized, instead of employing it to reduce the normal temperature θ, and consequently the back pressure of the condenser, we may reduce in the same proportion, viz, 37 per cent the volume of the air pump, and thus diminish sensibly the resisting work of this member. The work T a of this pump is

$$T\ a = O + (1.03 - p')\ s\ l;$$

an expression in which O is the work due to the exhausting of the water and air, and to friction; s, the area of piston in sq. cent.; l, the stroke; p, the mean pressure in the condenser during a stroke of the piston. Keeping in view the preceding, s may be replaced by

$$s' = s\ (1 - .37) = .63\ s$$

and substituting

$$T\ a = O + (1.03 - p')\ .63\ s\ l.$$

Allowing that O remains the same—a supposition not favorable to our case—then

$$\frac{T\ a - T'\ a}{T\ a - O} = 1 - .63 = .37.$$

(17.) The third condition mentioned in (§ 12) with reference to the duration of the stroke of the piston, seems to have received no attention in the various projected engines. This element of the problem has always been made subordinate to considerations having no reference to the development of power. This will be seen by the following tables, taken from examples given in the work of M. Gaudry, Traité des Machines.

It appears by these tables that the duration of the stroke varies between 0″.375 and 1″.200, and without any relation to the elements of motor power (pressure, diameter, and velocity of piston). It appears that it has been determined only after the diameter of the wheels or the pitch of the screw, with the view to obtaining a given

Names of Vessels.	Power.		Steam.		Piston.		Revolutions per minute.	Wheels.		Time of stroke, in seconds.
	Nominal.	Real.	Pressure, atmos.	Cut-off.	Stroke, meters.	Diameter, meters.		Diameter, meters.	Velocity per sec., meters.	
Parisien No. 2.	120	....	1.5	.60	1.00	1.25	34	4.63	8.239	.937
Parisien No. 4.	240	....	1.5	.70	1.20	1.45	34	4.70	8.836	.937
Papin No 9.	125	....	4.0	.30	.91	.86	36	4.65	8.760	.833
Napoleon.	120	148	6.0	.40	1.36	.56	36	3.95	7.460	.832
Express.	450	450	5.0	.25	1.20	1.20	35	5.30	9.707	.857
Papin No. 6.	260	....	3.5	.25	2.25	1.90	28	5.70	8.187	1.071

Names of Vessels.	Power.		Steam.		Piston.		Revolutions per minute.	Screws.		Time of stroke, in seconds.
	Nominal.	Real.	Pressure.	Cut-off.	Stroke, meters.	Diameter, meters.		Pitch, meters.	Velocity of propeller.	
Encounter.	360	643	1.0	.75	.68	1.40	80	4.50	6.000	.375
Arrogant	360	623	1.0	.75	.60	1.40	60	4.50	4.500	.500
Niger	400	919	1.7	....	.45	.91	75	5.10	6.375	.400
Termagant, geared 2 to 1.	620	1,351	1.5	....	1.06	1.24	36	5.40	6.520	.833
Napoleon, geared 2 to 1.	950	1 300	....	.80	1.63	2.42	25	9.38	7.816	1.200
Eylau.	900	....	2.5	.70	1.00	1.65	60	8.90	8.900	.500
Isly	650	....	2.5	.80	.80	1.56	55	8.00	7.333	.545
Chaptal.	220	340	1.0	.70	.70	1.00	70	6.40	7.467	.429
Primauguet	400	....	3.0	.30	.89	1.20	52	9.00	7.800	.576
Roland, geared 2 to 1.	400	....	....	.70	1.00	1.20	42	5.43	7.602	.714

velocity for the moving apparatus. In engines already constructed this duration can be modified only by changing the velocity of the piston, and this by diminishing or increasing the admission of steam. Under all circumstances where the resistance to be overcome will allow of a diminution of this velocity it will be advantageous to make it. But when we contemplate the construction of an engine, and observe that we can vary within certain limits the diameter of wheels and screws, the angular velocities, and the rate of gearing, we may realize the advantages of a long stroke of the piston. For example, the vessels Encounter, Niger, Arrogant, Termagant, whose strokes are respectively .375, .400, .500, .833 seconds, might have been so constructed as to make but 25 turns per minute, like the Napoleon, by means of suitable gearing or otherwise.

We may put eq. (7) under the form

$$\mathrm{T}\,c\,i = \tfrac{1}{3}\,\mathrm{S}\,\mathrm{L}\left[(\mathrm{P}-p)\frac{1}{1+r}\cdot\frac{q^2\,(650-\theta)^3}{4\,\tau^2\mu^3\Sigma^2(\Theta-t)^2} + 3\,p\right];$$

replacing the cosine by its value in terms of the arc, and stopping at the second term of the series, which gives this value. It will be seen that, all other things being equal, if we can vary the time of the stroke of the piston, the portion of the work due to the retardation of the condensation will diminish proportionally to the square of this time.

(18.) Resuming the principal results furnished by the discussions of the formulas relative to the injecting condenser, we make the following deductions.

1st. There is no maximum rate of injection. The vacuum of the condenser has no other limit than the weight of the valves of the air pump, and the portion of the work due to the normal counter-pressure can be reduced about 71 per cent.

2d. There is an advantage in increasing the vacuum space of the injecting condenser. By increasing it five times, the work due to the retardation of condensation will be diminished 28 per cent; increasing it ten times, it will be reduced 42 per cent.

3d. By injecting the water in a state of fine division, this same work may be reduced 71 per cent. If the second and third reductions are realized at the same time, their combined effect will be (calling $\mathrm{T}\,r$ the work due to the retardation), $\mathrm{T}\,r\,(1-.42)\,(1-.71)=17\,\mathrm{T}\,r$.

The total reduction then is $\dfrac{\mathrm{T}\,r\,(1-.17)}{\mathrm{T}\,r}$ $=83$, or 83 per cent.

4th. The actual rate of injection may be reduced about 37 per cent.

5th. It is advantageous to make the time of the stroke of the piston as long as may be consistent with the work to be done.

(19.) To show the importance of the advantages resulting from the reductions of work just mentioned, it only remains to determine, by some examples, the relation between the resisting work of the condenser and the developed motor power. I shall do this, theoretically, by means of some formulæ I have obtained, and practically by the use of diagrams, drawn with great care by an ingenious contrivance made by M. Farcot. These diagrams were constructed by M. Demondiser, chief engineer of the government manufactories, figs. 3 to 11.

We may observe that, in each diagram the curve determines three areas, viz, the

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Fig. 3.

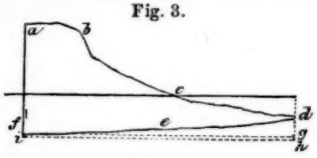


Fig. 4.

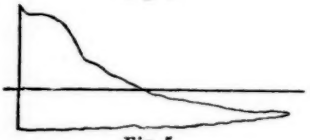


Fig. 5.

Fig. 6.

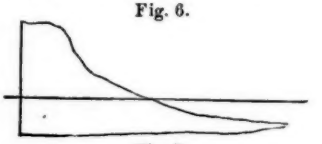


Fig. 7.

Fig. 8.

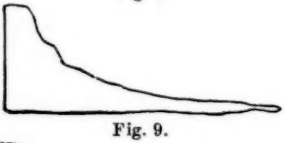
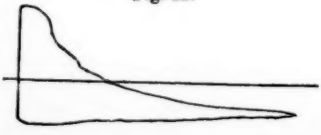


Fig. 9.

Fig. 10.

Fig. 11.



area $a\ b\ c\ d\ h\ i$, fig. 3, which represents the developed power per sq. cent. of surface of the piston; that is, the quantity

$$\frac{\mathrm{T}\ m}{\mathrm{S}} = \mathrm{H\ E}\left(1+l\frac{\mathrm{L}}{\mathrm{E}}\right);$$

the area $f\ g\ h\ i$ representing the portion of the resisting work of the condenser due to the normal counter-pressure p, which I shall designate by $\mathrm{T}\ p$; that is, the quantity

$$\frac{\mathrm{T}\ p}{\mathrm{S}} = p\ \mathrm{L};$$

and the area $d\ e\ f\ g$ representing the other part of the work of the condenser due to the retardation of condensation, which I shall designate by $\mathrm{T}\ r$; that is, the quantity

$$\frac{\mathrm{T}\ r}{\mathrm{S}} = \tfrac{1}{3}\ \mathrm{L}.\frac{\mathrm{P}-p}{1+r}n.$$

I give in the following table the values of $\frac{\mathrm{T}\ r}{\mathrm{T}\ m}$, $\frac{\mathrm{T}\ p}{\mathrm{T}\ m}$, $\frac{\mathrm{T}\ c\ i}{\mathrm{T}\ m}$, deduced separately from the aforementioned diagrams, from eq. (8), and also eq. (10), to a condenser modified conformably to the consideration in § 12–16.

The engine which furnished these diagrams made 29 revolutions per minute, and its condenser had a vacuum space one-fifth the capacity of the cylinder. The valves had but a very slight lead. In the diagrams the line of perfect vacuum was determined by the pressure p observed by the manometer of the condenser, and the portion of the initial ordinate below the atmospheric line. The values of n, introduced into eq. (8), were determined by the diagrams. As there was some uncertainty about the true position of the point of contact of the arc of the parabola with the line parallel to the atmospheric line, there resulted also some indecision as to the true values of $\frac{\mathrm{T}\ r}{\mathrm{T}\ m}$, and consequently of $\frac{\mathrm{T}\ c\ i}{\mathrm{T}\ m}$ deduced from that formula. It will be readily understood that the values deduced from the diagrams are still less precise. There should be, then, some differences in the results from the diagrams and those deduced from the formulæ. But they approximate sufficiently to allow the conclusion that $\frac{\mathrm{T}\ c\ i}{\mathrm{T}\ m}$ ranges between 12 and 14 per cent, or a mean of 13 per cent, in which $\frac{\mathrm{T}\ r}{\mathrm{T}\ m}$ figures for seven per cent, and $\frac{\mathrm{T}\ p}{\mathrm{T}\ m}$ for six per cent.

Numbers in the Order of the Diagram.	Pressure in the cylinder before cut-off, H.	Normal pressure in condenser, p.	Admission into cylinder, $\frac{E}{L}$.	Duration of condensation. $\frac{n\,L}{L} = n$.	By Diagrams.				By Equation (8), $T\,ci = \frac{1}{2}\,S\,L\left(\frac{P-p}{1+r}\,n + 3\,p\right)$.				Modified Condenser, $T\,ci = \frac{1}{2}\,S\,L\left[\frac{P-p}{1+r} \times \frac{1}{2}(1 - \cos\frac{\Sigma'}{\Sigma}) + 3\,p\right]$ $V = z,\ \Sigma = 10\,\Sigma'$ $\mu = 2\,c\,m = .03$ k.		
					Numbers proportional to $\frac{T\,m}{S}$, or area $a\,b\,c\,d\,h\,i$.	$\frac{T\,r}{T\,m}$	$\frac{T\,p}{T\,m}$	$\frac{T\,ci}{T\,m}$	$\frac{T\,m}{S} = \mathrm{H\,E}\left(1 + l\frac{L}{E}\right)$	$\frac{T\,r}{T\,m}$	$\frac{T\,p}{T\,m}$	$\frac{T\,ci}{T\,m}$	$\frac{T\,r}{T\,m}$	$\frac{T\,p}{T\,m}$	$\frac{T\,ci}{T\,m}$
	kil.	kil.													
No. 1, Fig. 3.....	8.09	.092	.31	.72	2.780	.082	.061	.143	2.081	.083	.044	.127	.017	.014	.031
No. 2, Fig. 4.....	8.20	.076	.22	.78	2.482	.077	.064	.141	1.769	.077	.043	.120	.015	.017	.032
No. 3, Fig. 5.....	2.84	.069	.29	.73	2.434	.071	.059	.130	1.848	.083	.037	.120	.016	.017	.033
No. 4, Fig. 6.....	8.09	.088	.21	.88	2.324	.077	.067	.144	1.662	.083	.053	.136	.014	.018	.032
No. 5, Fig. 7.....	2.58	.088	.30	.79	2.280	.071	.065	.136	1.904	.099	.046	.145	.014	.016	.030
No. 6, Fig. 8.....	8.09	.076	.11	.94	1.702	.065	.077	.142	1.090	.064	.069	.133	.011	.028	.039
No. 7, Fig. 9.....	8.09	.075	.15	.84	1.872	.062	.065	.127	1.315	.080	.056	.136	.004	.023	.027
No. 8, Fig. 10.....	8.09	.075	.085	.82	1.528	.065	.078	.143	.912	.047	.082	.129	.009	.033	.042
No. 9, Fig. 11.....	8.09	.070	.13	.80	1.850	.030	.063	.113	1.221	.061	.057	.118	.012	.024	.036
Mean.....	....	....	....	....	....	.069	.066	.135	.....	.075	.054	.129	.012	.021	.033

It will be seen that, in the actual condenser, $\frac{T\,ci}{T\,m}$ varies between .118 m. and .145 m., the mean being .130 m. This ratio, in the modified condenser, gives a mean of .033 m., being an economy of 6.5 per cent of developed power, not including the economy in the working of the air pump.

(To be continued.)

MALLEABLE CAST IRON.

Translated from "Le Génie Industriel."

For the production of this material most of the German founders use first fusion pig, free from sulphur and phosphorus, or Scotch pig. Styria also furnishes a suitable iron, which can be used only in the north of Germany, however, on account of the expense of transportation and high duties. On account of the competition of wrought iron, great cheapness is very essential to its sale.

The makers keep secret the brand or grade of iron which they employ, but it is well understood that the brands are not the same in different establishments. The iron is melted in plumbago crucibles, holding about 30 kilog. They are covered with porcelain lids, to keep out impurities and cinders which reduce the high heat requisite for the process. The fire, in which the crucibles are placed, is from .630 m. to .940 m. square, and is surrounded with bricks of porcelain earth. The use of blast is not advantageous, since the economy of time is offset by a greater consumption of coke. The natural draught of the chimney is sufficient when the furnace is properly constructed. As we have said, an essential condition of success is a high heat at the moment of pouring. Practice enables the founder to estimate the heat of the furnace, and he recognizes the precise mo-

ment by plunging a bar of red hot iron into the crucible, from which, upon being withdrawn, the metal flies off in sparks. The crucibles are raised with tongs, with curved jaws, and the pouring is done with all possible promptitude—the surface being first cleaned.

By cementation the casting acquires the properties of wrought iron, having some analogy to steel. The operation consists in subjecting the castings to a prolonged red heat, in a bath of pulverized red hematite. They are arranged in boxes of cast iron called muffles. It would seem that the cylindrical form ought to be most advantageous for the boxes, but practically they are simply square, and with covers which should keep out entirely the least access of air.

In arranging the castings in the boxes they are placed in layers alternately with layers of hematite. The cementing furnace is very simple. The grate is in front, and the draft of the chimney carries the hot air around the boxes. The heat should be conducted with care, starting rather vigorously, in order to reach quickly the desired temperature; then supplying the furnace at regular intervals. The cementation lasts three, four and five days, according to the size of the pieces. A charge is about 350 to 450 kilog. of castings. In arranging the charges large pieces should not be mingled with small, and those muffles containing the larger pieces should be placed in the furnace first. On the other hand the smaller objects are placed on the sole of the furnace. Without these precautions many pieces may be burned, or badly decarburized—the latter becoming something intermediate between iron and steel. When the operation is deemed complete, the fire is allowed to fall, but the furnace is not uncharged until it has gradually cooled. Practice plays an important part in the management of the firing, as the temperature can be judged of only after prolonged experience. Next to the fuel, the greatest expense is the cementing boxes, which are often serviceable only for a single operation.

THE PENNSYLVANIA STEEL WORKS.—These works are producing eight heats of five tons each in one "turn" of twelve hours. This is remarkably fast working, and proves the excellence of the machinery and of the management. The entire eight heats of iron are melted in one charge of the cupola, as improved by Mr. Pearse.

AMERICAN RAILWAYS.

AN ENGLISH VIEW OF THEIR MERITS AND DEFECTS.

From the correspondence of "Engineering."

In the mechanical construction of American rolling stock the bogie plays a most conspicuous part, and is the chief feature of difference between our own practice and that of American engineers. In America its adoption is universal, whilst in this country, in actual practice, it is very little known. There must, of course, be some substantial reason for so great a difference between the practice of two countries so intimately connected.

In the first place, then, the permanent way in America is generally understood to be inferior to our own, and on this point I think very little doubt can exist. The section of rail is usually considerably lighter than with us, and is out of all proportion to the loads it has to carry. The roads are scantily ballasted, and the use of ballast at all is the exception, and not the rule. Much has also been said about the inferior quality of the rails sent to America, but I would venture to say the rails are "more sinned against than sinning," as I shall presently show.

Those who have not had an opportunity of examining the permanent way can form no idea of the rough character it presents. The rails are laminated, bent, crushed, and out of line to an extent entirely unknown in this country. The "fishing" of the joints is also done in a very inferior manner, and there are thousands of miles laid without the joints being fished at all. On one line, where I was detained owing to a goods train being off the track—the result of a broken rail—I took the opportunity of noting the inequalities of the road, and measured the distances the rails had parted asunder at some of the joints; I found in many places the gaps to vary from 1 in. to 3½ in., and the ends of some of the rails thus separated were off the sleepers altogether. The breaking of the rail in question, therefore, ceased to be a matter of surprise. In winter the ground is frozen, for months together, almost as hard as granite, and, practically, during this time no repairs can be done to the road; to make the matter still worse, in freezing it often happens that one rail is elevated 6 in. or 7 in. above the level of the other. These "frost-blisters," so called, are of fre-

quent occurrence, and the unevenness of the line is a source of great trouble and danger.

Some idea may be formed from this of the difference between the American permanent way and our own. It is to such roads as I have described that American engineers have had to adapt their rolling stock, and for them the bogie is an *absolute necessity*, as it enables a carriage to pass over such roads as I have described with less oscillation, vibration, or jolting than is experienced in the railway carriages in this country.

It is only justice, however, to say here that, with increased capital and other favorable circumstances, many of the American lines are being gradually reconstructed and the permanent way made generally equal, and, in some respects, superior to our own; rails of heavier and better sections are being laid down, and steel rails, with steel fish-plates, of greater length than ours, are being largely introduced.

It may, therefore, be worth while to consider if the Americans can construct carriages to pass smoothly over rough roads, whether it be not possible for English engineers to construct stock which, at all events, will run with some degree of comfort over lines which are incomparably superior. The chief difference between the two is, that in the American arrangement, all, or at least the greatest part, of the motion arising from the irregularities of the road is absorbed by the bogie, and not transmitted to the body of the carriage, whilst with us every unevenness in the road is at once communicated to the body of the carriage, the result being that our carriages oscillate at times to a frightful extent, which not only unpleasantly affects the passengers, but is a source of considerable extra expense to the railway companies, for the carriages require to be much heavier than would otherwise be necessary, to withstand the shocks caused by the whole weight of the carriage being thrown violently from one side to the other; the flange friction and also the friction on the ends of the journals is much increased, and the damage to the tyres and permanent way consequently much greater.

It is often a matter of wonder why omnibuses traveling over roads which for evenness bear no comparison to a railway should be so much lighter in proportion to the load they carry. Put hornplates on an omnibus, and you will soon shake it to pieces, and no passenger would ride in it a second time. In an omnibus, however, the irregularities of the road are absorbed by the springs, and not transmitted to the body of the vehicle, and why should not the same principle be carried out in railway practice? Some time ago Mr. Attock, the carriage superintendent of the Great Eastern Railway, successfully interposed india-rubber blocks between the body of the carriage and the frame, in order to prevent the noise being transmitted; the arrangement having also other advantages. The comfort to passengers was found to be so great from this simple introduction that most of our railway companies immediately adopted it, and few carriages are now constructed without the india-rubber blocks. If this principle were carried a little further it would be comparatively easy, not only to prevent the transmission of sound, but also of violent motion arising from inequalities of the road, and the principle embodied in the swing bogie of America would accomplish this, and might easily be adapted to the existing rolling stock.

Having said so much in reference to the principle and utility of the bogie, I may proceed to another distinctive feature in American rolling stock—the chilled cast-iron wheel. The Americans are perfectly familiar with the construction of our carriages, wagons, and locomotives, and the best English examples have been tried on their lines of railway. I saw in the shops of several railway companies numbers of English-made wheels, both wrought iron and wood; some of these had been tried, but very soon broke up, and were frequently the cause of accidents.

However anxious American engineers are to adopt the best arrangements of their own or other countries, we have not been able to offer them wheels at all approaching in strength, durability, and cheapness to their cast-iron chilled wheels.

It was shown both in a recent paper* and during the discussion which followed upon it, how much stronger, cheaper, lighter, and enduring these wheels as manufactured in America (and also on the Continent, where they are largely used) are to our own. Since the Americans have paid us the compliment of trying varieties of wheels manufactured in this country, we might return the compliment, and see how far their wheels would be valuable to us here. One of our most enterprising locomotive super-

*Read before the Institute of Civil Engineers.

intendents, Mr. William Adams, has already made an experiment with them, and in reply to an inquiry as to the result, says, that after running them for a considerable length of time under the bogie of one of his heavy engines, he could see no traces of wear at all, and that the surface in contact with the rail was simply polished.

The American wheels are made from the best cold blast charcoal iron, the strength of which is exceedingly great, as may be judged from their test bars standing a tensile strain of 18 to 21 tons per square inch of section; and not only is the tensile strength great, but their tenacity is equally striking. In breaking the pigs I have seen them bend to a very visible extent before separating. Scotch iron in one or two instances has been attempted, mixed with superior American iron, but without success, and all such admixtures are regarded with extreme suspicion, and are only attempted by inexperienced or unprincipled manufacturers. It is worthy of remark that even among the better class of charcoal irons there is almost as much difficulty in obtaining suitable material (with the requisite chilling and other properties) for these wheels, as there is in selecting suitable material for good Bessemer steel. In America, out of a considerable number of generally excellent irons there are not more than half a dozen which have obtained a special reputation for this class of work, among them the Salisbury, the Richmond, and more recently, and with remarkable success, the Acadian charcoal iron, which, notwithstanding the very high duty of nearly £2 per ton, has been imported from Nova Scotia for the manufacture of chilled wheels by Messrs. Whitney and Sons, of Philadelphia.

In Germany, too, where these wheels are greatly in vogue, and where their manufacture has been conducted with special skill, the range of selection of really suitable irons is comparatively small. The cost of such iron ranges from £6 10s. to £7 10s., or even more, per ton in the States, and the price of wheels 2 ft. 9 in. diameter, weighing from 400 to 550 lb. ranges from £2 15s. to £3 7s. 6d. per wheel or an average of about £14 to £14 10s. per ton. The distances travelled by these wheels have been variously stated, but the average may be safely taken as from 100,000 to 150,000 miles. I may just mention that the wheels are not keyed on, but simply forced on by hydraulic pressure, varying from 20 to 30 tons. There is nothing peculiar about the axles employed, but the axle-box is simple and convenient in construction. On many lines the bearing is formed by running white metal into a brass frame, which is found to be much more economical than brass alone. The distance these bearings will run is from 50,000 to 55,000 miles, and afterwards they are again lined up. The journals are lubricated with crude surface rock oil from the wells of Pennsylvania, the cost of which is only 6d. per gallon; in England we pay from 3s. to 4s. 6d. per gallon.

It is very pleasing to note the efforts made by all the railway companies in America to secure the greatest amount of comfort to the passengers. The subject of ventilation has occupied considerable attention, and ingenious contrivances for effecting this most desirable object are very numerous and interesting. It is a very easy matter by opening a window to admit a rush of air into a compartment, as many of us know to our cost, and it is very uncomfortable to be stifled by having the windows closed altogether; between the two—in this country—we have very little alternative; there are certainly what are termed ventilators over the doors, but they are all but useless, not being constructed on any correct principle for the proper circulation of air.

Now, the Americans have a very simple plan for exhausting or drawing the impure atmosphere out of their carriages, which is the principal difficulty experienced in all attempts at ventilation. On one occasion, whilst traveling in a sleeping car, I felt a strong inclination to smoke a cigar; I asked the attendant if it were permitted, and was informed that such a thing was never allowed; but, seeing that I was an Englishman—and with that desire which, I must say, evinces itself at every turn to show attention to our countrymen—he said: "Though it is not allowed, Sir, I will fix you up so that you can smoke your cigar and no one shall know. I was curious to see how this was to be done, as there were passengers sleeping on every side who would certainly have complained had they perceived anything so unusual. Presently he appeared with a small flat board about 7 in. wide and 13 or 14 in. long. "This, Sir, is the ventilator, which I shall put in the window, and you can then smoke as much as you like." He then opened the window, and inserted the board so that it projected at right angles to the carriage-body, immediate-

ly causing a strong outward current of air which took away the smoke. The principle of it is easily seen: the board causes a rush of air in front of the window, to the distance it is projected, and a vacuum is thus created on the other side of the ventilator, and the air exhausted from the carriage. With this simple contrivance—and the same principle is carried out in various ways by the Americans—for exhausting the foul air, and by admitting the pure through a considerable area of fine wire-gauze, either in single sheet or a double, placed so as to leave a space between the two—instead of allowing the air, as is the usual practice here, to rush through unchecked openings injudiciously placed, causing dangerous draughts—we should have a very efficient method of ventilation.

I would next make a few remarks on their locomotives. It has been said that the difference between between English and American locomotives is in outward appearance only: this may be so to a great extent, but I think there are points of detail (and points of detail are sometimes very important) which are worthy of note and consideration. The first glance at an American locomotive gives you the impression of an old Bury engine with a bogie in front and a great deal of Birmingham finish, and one is inclined to imagine that American engineers cannot have seen English locomotives, but this idea is soon dispelled when they are examined in detail or their performances witnessed. The curves on some of their main lines are very severe: as an example, those on the Pennsylvania Central above Altoona are set out to a radius of 600 ft., not for short distances only, but in long lengths of continuous curves. The heavy traffic is worked over this section of the line by means of six-wheeled coupled engines, which in passing round the curves have comparatively no flange friction at all; the bogies of these engines have a swing motion similar to that of the carriages, which leaves the engine, to a great extent, free in front; the bogie wheels are made to correct guage, and, in order to prevent grinding or flange friction, the leading and centre driving wheels are virtually without flanges, the leading wheel having no flange and the middle wheels being very slack in guage, whilst the trailing wheels fit the gauge exactly. From this it will be apparent that there are no binding points throughout the whole wheel base. The tyres of the two middle wheels are made much broader to allow the necessary lateral travel. Four-wheeled coupled engines are also sometimes made without any flanges on the driving wheels.

The framing is made of square bar iron, well put together; plate-framing has been tried and abandoned. The slide valves are horizontal and worked by means a rocking shaft; direct-acting valves have been tried, but given up, and all engines with such valve arrangements sent from this country have been altered.

Instead of the balance weight to the link motion, a simple arrangement of coil spring has been substituted, which has a neat appearance and enables the reversing lever to work more freely.

A "Ramsbottom" arrangement of screw-reversing gear has on some lines been adopted in combination with the reversing lever, so that either one or the other can be used. The eccentric straps and sheaves are of cast iron, neither brass nor white metal being used. They wear much better, are much cheaper, and give no trouble. The smoke-box is simply a continuation of the boiler plates, and the smoke-box door is of cast-iron. This makes a strong, substantial arrangement, and at the same time cheap and easy of construction.

Steel boilers are becoming very general, and were to be found in the locomotive shops of all the railways I visited, and steel fire-boxes were also very largely employed. American engineers have no hesitation on this subject, and could they obtain good steel plates as cheaply as we can in this country, the use of iron plates would soon be abandoned. The fire-boxes are only $\frac{1}{4}$ in. thick, and some of the locomotive superintendents informed me that, were it not for the difficulty of the stays, they would have them still thinner. Thin plates are advantageous in two ways; steam is generated more rapidly and economically, and they admit of easy expansion.

Steel fire-boxes have broken in this country, but this, I believe, was owing in a great measure to the thickness of the plates. Whilst we are hesitating in this country about the use of steel boilers, the Americans have passed through the field of experiment, and are now largely using them. I saw a steel boiler tested at Pittsburg; the plates were $\frac{1}{4}$ in. thick; the boiler was 38 in. diameter and 4 ft. long, with flat ends stayed longitudinally. Some of these stays gave way with a pressure of 780 lb. on the square inch, and one end of the boiler was blown

out, the thickness of the plates being much greater than in the barrel. Before bursting, the barrel stretched 4 in. in circumference beyond its original dimensions. . .

The weight on the driving wheels of the 4-wheeled coupled engines is from 8 to 12 tons, being very excessive for the prevailing light sections of rails.

We are astonished when accounts reach us of the number of rails broken in America, but to any one who has been over there and investigated the subject, it is a matter of surprise that the number is not greater. The weight of the rails, generally, is from 56 to 60 lb. when new, but, but after several years' hard wear this will be reduced to about from 48 to 52 lb. The rails are so crushed in many places as to reduce the section to the web and bottom only. That such rails should break with engines of 30 to 35 tons, with 12 tons on an axle, is certainly not surprising.

Though the engine plays a destructive part in the wear and tear of the rails, the wagon stock is equally, if not more, destructive. The worst feature in this department is the inefficiency of the springs under the wagons. India-rubber is employed to a great extent, and thousands of wagons are provided with nothing but small blocks of rubber of such insignificant dimensions as virtually to render the wagons without springs at all; and in winter time, especially, when the ground is frozen as hard as stone, and when the greatest amount of elasticity in the stock is required, these small blocks of rubber are practically of no value, and wagons weighing, when loaded, from 20 to 25 tons, are running dead over the frozen track. Some of the wagons, provided with steel springs, are very little better. I measured a number of the springs and found them actually not to exceed 12 in. between the bearing points, and far too stiff and rigid to afford any relief to the superincumbent load. I have seen a number of anxious American letters on the subject of rails sent out from this country, both iron and steel; but of what extraordinary material must a rail be made to stand such punishment as I have referred to, not to mention other causes which I will not now attempt to discuss.

As a brief comparison of the relative amounts of dead weight to the load carried would, perhaps, be interesting to your readers, I may mention that the American carriages generally carry about 70 passengers each. The weight of the carriages, formerly, was from 12 to 15 tons, but those recently constructed are no less than 15 to 17 tons.

The "drawing-room cars" (so called from a fear of making any avowed distinction of class, such as first, second, and third) are still heavier, while the weight of the sleeping cars are from 20 to 35 tons. The greatest difference, however, between the practice of the two countries lies in the dead weight to the paying load in their goods traffic. The largest proportion of their freight cars are covered goods wagons, measuring from 28 to 30 ft. long and about 8 ft. 6 in. wide, with a bogie at each end. The total weight of these wagons is from 9 to 11 tons, and the load they are required to carry is from 9 to 12 tons, or, practically, an equal weight of dead load to the paying weight carried.

So miscellaneous are the weights and dimensions of our English wagons that it is difficult to classify them, but taking a fair average we may safely assume that as regards dead weight we have an advantage of at least 30 per cent. in our favor.

FOUNDRY ECONOMY.

In a late lecture on "Applied Mechanics," before the Society of Arts, Mr. John Anderson, C. E., Superintendent of Machinery to the War Department, after familiarly describing the distinctive properties of cast and wrought iron and steel, proceeded to speak of the molecular structure of metals. All metals, he said, are crystalline, but the crystallization is better observed in some metals than in others. In cast iron, especially, it is very apparent. The crystallization of cast iron is governed by a natural law. This law was first pointed out, to the best of his belief, a few years since, by Mr. Mallet, and is this: When cast iron is in a liquid state—when the molecules have sufficient heat amongst them to give liquidity—the direction of crystallization is determined by the lines into space which the heat takes. When this law was first started it was received with skepticism, but ever since the law had been pointed out, he (the lecturer) had never observed in any piece of broken metal an example to the contrary. If we introduce into castings irregularity of figure, or anything which creates currents outwards in various directions, then we get wrong; we introduce lines of weakness. According to this law, guns up to this time have always been made wrong.

The Americans are acting upon this law in everything they are doing, and that gun of theirs which some time back came to this country, almost like a soda-water bottle in shape, was constructed in strict accordance with this law, and, therefore, possessed the utmost strength attainable with the same weight of metal. The molecular appearance of cast iron depends on the rate at which the heat is hastened out of the casting.

As to the goodness of cast iron, goodness for small castings is not goodness for an hydraulic cylinder; goodness for an hydraulic cylinder is not goodness for a gun. Density is a quality good for both the latter, but we don't want ductility for an hydraulic cylinder, but for a gun it is required; for the hydraulic cylinder we want very great density. As a rule, the hardness of cast iron or cast steel depends upon three things: 1, on the quantity of carbon which the mass contains; 2, on the heat to which it was raised before carrying the heat out of it; and 3, on the rate at which that heat is hastened out it. All these conditions go to determine the character which cast iron or cast steel assumes. In casting iron in moulds, where hardness is wanted, some method is adopted so as to carry the heat out rapidly, and where softness is required, means are taken to allow the heat to go out slowly, and it does not much matter what the method is so long as it is effectual. The hardness of steel depends upon the quantity of carbon which it contains, and on the rate at which the heat has been carried out of it. After alluding at some length to the founder's art, the lecturer proceeded to speak of the casting of a fly-wheel, pointing out that the only thing which would preserve such a casting intact whilst cooling was to take care that every part should cool at the same rate. The arms, being least in substance, would naturally cool first, but they must be kept hot by covering them with fire or by any other convenient means. If we require a particularly good casting, it must be cooled slowly.

Many of the difficulties of the caster would be got rid of if we could prevent the formation of the gas within the mould. The Americans are very much more careful in this respect than we are, and this is the explanation of their cast-iron guns standing so well. Mr. Babbitt uses old firebricks, which after, say ten years' service, have not changed color; any firebricks at all discolored he rejects. He grinds these to a powder, and thus gets a perfectly pure and refractory material for his molds, using pipeclay, the best material for the purpose, to render it adhesive. The mold is first made red-hot, and this red-hot mold then receives the metal. Not a particle of gas is generated by the mold. Another American founder, Mr. Hains, uses kaolin, which he obtains from England (Devonshire), and treats it in a similar way to that in which Mr. Babbitt treats his powdered firebricks and pipeclay. To show the earnestness of our American competitors—and we shall have them as competitors—they resort to the method of of taking the heat out of the castings in the way which would be least injurious to them. They try to establish the conditions of a built-up gun in a cast-iron one, to have every atom of the gun under tension. We English, as a people, must pay the same attention to natural laws as the Americans and the French are doing.

ELECTRICITY AS A MOTIVE POWER.

From the "American Journal of Mining."

Some time ago we touched lightly on this subject in an article entitled: "Electricity and Steam." We pointed out how much more expensive the former is than the latter, for the simple reason that the source of the first power is zinc, a product of art, and of the latter coal, a product of nature, also that if we add to the difference in price, the difference in the chemical equivalent which makes six pounds of coal as effective as 64 pounds of zinc, we obtain as a result that zinc will be more than 100 times more expensive than coal. But the difference in coal is practically even more than this. For the oxidation of the zinc acids are needed, also products of art, and for the oxidation of the coal or carbon common air, a product of nature, literally costing nothing at all. Now, as there is no reason whatever to suppose that electric engines are more perfect than our best steam engines, with all the modern improvements, for the reason that our experience in manufacturing electric engines is very small, and in the steam engines very great, we may confidently assert that the continual running of an electric engine for practical purposes would at the present day cost a thousand times more than the amount incurred by a steam engine, so that the amount of power obtained from the first, at a cost of ten dollars, would be obtained from the last at a cost of only one cent.

Notwithstanding this, we see from time to time inventors—who, by the way, are often apt to forget what should be the final question in regard to all enterprises; will it pay?—basing their experiments upon our present highly expensive sources of electricity, and contriving new combinations of currents and magnets, hoping by some scientific hocus-pocus combination to obtain a miraculous effect. Some twenty years ago there was a large electric engine mania among inventors, just as there is at the present day in regard to ice and cooling machines. Scarcely a month or even a week passed that some new combination of electro-magnets of peculiar form, was not exhibited, usually patented, as each inventor supposed his combination to possess such superior advantages to outdo all competitors in that line; often, however, the peculiarity insisted upon by the inventor, as a great advantage, turned out to be a defect, and the machine would perhaps scarcely go at all. We remember in this connection some machines remarkable for the total want of theoretical knowledge shown by the inventors. One of them had enormously elongated pole ends at the electro-magnets, the inventor erroneously supposing that their large surfaces of iron would exert great attraction, and not knowing that such elongated poles acted like attached keepers, absorbing almost all the attractive power developed by the coils; however, the machine was made on a large scale, at the expense of several thousand dollars, and when finished, showed much less power than the simple machine—in fact, it scarcely moved at all.

In order that the uninitiated reader may fully understand all this, and what is to follow, it is only necessary to state, that when a piece of soft iron is surrounded by a coil of insulated copper wire, and an electric current passed through this wire, the iron will become a strong magnet, and lose its magnetism at once when the current is interrupted. All that is necessary, therefore, to cause intermittent attractions is an intermittent contact with the electric battery, and these attractions will cause to-and-fro motions, which by means of a crank may be changed into rotary motion; or the intermittent magnets may be placed on the circumference of a wheel, and attract similar other magnets, or as many pieces of iron; the contacts with the battery being made and broken, by means of some automatic arrangment worked by the motion of the machine itself.

Numbers of such contrivances have been made, and may be seen in every physical cabinet; but in fact they are in a physical point of view mere illustrations, of the properties of electro-magnets. When considered in a mechanical point of view, they are mere toys; and in reality there never was a machine of this kind yet constructed, even on a large scale, which was in reality more than a toy.

But not only these so-called electro-magnets will attract one another, or attract iron, but the currents themselves will attract each other when running in the same direction, and repel one another when running in opposite directions.

This was discovered by Ampere in France, some 40 years ago, and has given rise to a new branch of physics, called electro-dynamics. It was first applied to moving machines by Mr. Vergnes, from France, living in New York City, who had made the study of electricity a speciality, and, in the ambition of his inventive genius, again overlooking the great ultimate question as to cost, constructed the largest electric motive engine perhaps ever made. It was repeatedly on exhibition, and was shown in the Crystal Palace, New York, at the world's fair in 1852. It worked admirably, and with seemingly considerable power, which, however, never was measured. It is a curious fact that in any machine of this kind the inventors always oppose most strenuously any such measurement. The battery used was enormous, many hundreds of cups and carboys of acids being in operation, so that the expense must have been ruinous.

In this machine Mr. Vergnes had wisely combined the attraction of the iron of the electro-magnets, with the attraction and repulsion of the currents themselves, according to Ampere's discovery; for the reason that the attraction of the currents, or rather of the wires conducting the currents, is comparatively very weak, so that quite a strong battery is required to demonstrate this attraction at all, while the attraction of electro-magnets will manifest itself most strikingly with a battery of one-hundredth part of the size of that required to cause the mere currents to attract each other. This fact is well known to every one who has ever experimented with voltaic batteries, currents, etc.

Taking all this into consideration, we cannot disguise our great surprise, that the newspapers should this week contain a glowing description of a so-called newly-invented

electro-motive engine of M. Griel, a French military officer, based on the action of currents on currents; asserting that all inventors thus far had confined themselves to the use of electro-magnets, and that here for the first time the laws of dynamical electricity have been brought into play.

Now the fact is, that if not in all, at least in most philosophical collections, there are pieces of apparatus, in which, on a small scale, this principle is illustrated, and Vergnes, mentioned before, has, with many others, put this principle in practice, but found that when discarding the use of electro-magnets entirely, the most advantageous effects were lost. No doubt Mr. Griel's machine would be stronger if advantage were taken of the powerful magnetic action acquired by soft iron under the influence of electric currents, in place of confining the power to the comparatively weak attraction and repulsion produced on the pure electro-dynamic principle.

The battery described for driving this machine is identical with Bunsen's, namely amalgamated zinc, diluted sulphuric acid, porous cups, strong nitric acid and coke. It appears to be of enormous dimensions, and of course correspondingly enormous expense.

The most curious thing, however, is the calculation of Mr. Griel, by which he attempts to prove that when using steam the expense increases in direct ratio of the horse-power obtained, and that when using his machine, it will only increase somewhat as the cube-root of the power obtained, as shown in the following table given by him:

Horse-power obtained.	Expense— Steam.	Electricity.
2	..	..
16	$8	$2
64	16	3
250	125	5
2,000	1,000	10

and conceding that for two horse power electricity costs 25 times more than steam, when using 250 horse power it becomes equal, and for 2,000 horse power it will be four times as cheap.

Now, the fact is that electricity, in the way he obtains it, is not only 25 times, but 1,000 times more expensive than steam, and that the calculation of relative reduction of expense for greater power is entirely false and erroneous.

To crown all, he states that he can apply his machine to railroads, and by means of an electro-magnet of his invention (most wonderful) cause the electricity to wash from the wheels of the machine upon the rails, and proposes to ascend any grade with the greatest facility.

It is now several years since M. Nickles, of France, who, we regret to say is recently deceased, proposed to accomplish the same thing by similar means, and about six years ago the same idea was again revived by an American inventor, who tried to prevent the slipping of the driving wheels on the rails by exactly this plan, making that part of the wheel which touched the rail a temporary electro-magnet. It was tried, at great and prolonged labor and expense, but given up as totally impracticable. One French inventor goes even further, and appears to have the intention of also driving the cars forward by his machine.

It is matter for surprise, that the editors and reporters of our public press, otherwise so well informed in matters political, religious and otherwise, are so little posted on scientific matters, as continually to be deceived by the pretentious claims of inventors. True men of science too often meet with cold contempt, while charlatans and deluded enthusiasts are received with almost superstitious credulity.

TORPEDOES.

From the "Pall Mall Gazette."

The strides which have been made within the last ten or fifteen years in the application of science to warlike purposes are nowhere more marked than in the use of electricity as a military agent. It is applied to military telegraphy, to signalling and reconnoitering purposes, to the determination of the ballastic powers of guns, to many naval uses, such as signalling and the simultaneous discharge of broadsides; to various experimental purposes, including the proof of guns; last, but not least, to the explosion of land and submarine mines. The history of the subject and its most recent phases were treated a few nights ago at the Royal Institution by the gentleman to whom above all others we are indebted for the development of this special branch of application of the science. The interest of Professor Abel's excellent lecture centered, however, in his account of what has been done in this country towards the establishment of a system of torpedo defence. It was the first authoritative utterance on the subject which has yet been heard, and the immense importance of

the question, combined with the secrecy in which it has thus far been shrouded, suggest the desirability of taking advantage of the occasion to say a few words about it.

Torpedoes form the most important class of those marine obstructions which are now generally admitted to be indispensable to effective coast and river defense. They are the active as contradistinguished from the passive obstructions. The importance of obstructing roadsteads, rivers, and harbors —of placing, so to speak, an outer belt or circle of defenses, external to the chain of forts, and even where no forts existed—has long been understood. It would be difficult to assign a date to the first employment of rude appliances of some sort for effecting this object; even submarine mines, which are a more advanced type of defense than piles and artificial barriers and fire ships, were used as far back as the sixteenth century, when they were employed, in 1583, by the Duke of Parma at the siege of Antwerp. The English used them against the French ships off Rochelle in 1628, and during the long lapse of years between 1628 and 1854, the subject was never wholly lost sight of. Always there were men with contrivances more or less ingenious, more or less impracticable, ready when the opportunity offered to revolutionize with their torpedoes the art of coast defense. But science was during that time in its infancy. The torpedoes in occasional use prior to 1854 were rude and imperfect, and the development of the subject was cramped by the absence of sufficient knowledge or study to enable electricity to be usefully employed as the agent of ignition. Thus the first torpedoes were of the mechanically exploding class. All sorts of plans were devised and all sorts of agents were employed—percussive, frictional, chemical, and clockwork. It is evident, however, that mechanical torpedoes can never be altogether satisfactory. They are open to one salient objection, viz, that once in position and ready for action they close the navigation alike to friend and foe, and there is always a certain amount of danger attending their manipulation. These evils have been attempted to be mitigated by various safety arrangements, so-called, the application or the removal of which, however, as often as not proves so dangerous as to furnish a formidable objection to their employment. Thus, when the Russians employed, for the defense of Cronstadt, mechanical torpedoes with a safety arrangement, which should have been removed at the last moment, they generally, for very good reasons of their own, neglected to remove it, and the torpedoes in consequence proved absolutely innocuous. Again, the removal of the torpedo is frequently a source of danger, and several instances have recently occurred in America of loss of life under these circumstances. Nevertheless, mechanical torpedoes will probably always possess a certain value, as on remote foreign stations, where the means of defense have to be extemporized on an emergency, or for what are called "drifting" or movable torpedoes. This abortive employment of torpedoes in the Russian war of 1854–5 marks the first systematic use of the instrument in European warfare on a large scale. In 1855 electrical torpedoes were attempted; and by 1859 the Austrian Government had succeeded, with the assistance of Baron von Ebner, in perfecting a sufficiently simple and practical system of electrical torpedo defense, which was applied, although without results, at Venice. Until lately the Austrians may be said to have headed the science, and their exhibition of a complete system of torpedo defense formed an interesting part of the display at Paris in 1867. No really important illustration of the great value of torpedoes was furnished until the late American war, when these agents were employed in many forms, chiefly by the Confederates, and with remarkable results. No less than twenty-five vessels of the Federal navy were destroyed and nine others were injured by the explosion of torpedoes; and thus an impetus was given to the subject, similar to that which breech-loading derived from the Bohemian campaign of 1866. If any one wishes to study the detailed application of torpedoes during the American war, he can hardly do better than consult Von Scheliha's *Treatise on Coast Defense*, where also he will find the following important deductions from the experience obtained during this contest: "No forts now built can keep out a large fleet unless the channel is obstructed." "No fleet can force a passage if kept under fire by obstructions." "*In no single instance did a naval attack succeed when the channel had been obstructed, and in no single instance did it fail when the channel had remained open.*"

The attention of our Government was directed to the subject towards the close of 1863, when a committee was appointed, at the suggestion of Colonel Jervois, R.E., for the thorough practical investigation of the

whole question of marine obstructive defense. From that time until the latter part of last year, the committee was actively engaged in an experimental inquiry, and the result has been the compilation of a report which is likely to prove the most complete and exhaustive treatise on the subject yet produced. Hitherto the report has been treated as confidential, and it is, no doubt, desirable that the details of the committee's recommendations should remain secret. But no objection can be urged against the production of so much of the report as would inform the public in general terms of the successful termination of the committee's labors, and of the broad results purchased at a not inconsiderable expenditure of time and money. It would be satisfactory to have some definite and authoritative assurance that the national interests have not been neglected in this vital question of defense, as well as an assurance that the recommendations of the committee will be duly and practically accepted. We observe that the very inadequate sum of £2,000 has been taken in this year's estimates for the provision of torpedo equipments, and for further inquiry and instruction. The gunnery ships of Portsmouth and Plymouth, and the Engineer's School at Chatham, now regularly include the use and management of torpedoes in their course of instruction.

To return to the torpedoes themselves. We have stated that mechanical torpedoes, however occasionally useful, are necessarily imperfect and, to a great extent, dangerous appliances. The advantages which attach to the application of electricity to the explosion of torpedoes are great and manifest. Torpedoes of this class may be placed in position with absolute safety to the operators; they may be rendered active or passive at any moment, as desired; they thus do not close to friendly vessels the channels which they guard; they can be stationed at any depth beneath the surface; their action is generally very much more certain than that of a mechanical torpedo; and they can be removed with perfect safety. As in the case of torpedoes of the mechanical class, the arrangements for securing action may be almost infinitely varied. Frictional, voltaic, dynamo-electric or magnetic electricity may be employed, each possessing specific advantages or objections; and the circuit which determines the explosion may either be completed by the contact of a passing vessel or at the right moment by an operator on shore. The latter system, which admits of many modifications, is probably the more simple; but it imposes the necessity for great vigilance, promptness, experience and harmonious co-operation on the part of the operators. It is also inapplicable at night or in thick weather, and might even fail under the dense smoke of a hot action. A more generally efficient plan is that of contact-exploding torpedoes, which are either exploded by their collision with a ship, or by the vessel striking a circuit-closing arrangement moored near the surface of the water, whereupon either the torpedo, moored at some depth beneath, is instantly exploded, or a signal is furnished to a station on shore, which indicates to an operator the particular torpedo to be fired, and when to fire it. It is essential in this arrangement to adopt a plan which, while sensitive to the passage of a vessel, shall not be disturbed by the simple action of the waves. These conditions include the necessity for simplicity of mechanism and a combination of sufficient but not excessive delicacy of action, with permanence during long immersion; but the problem, though difficult, is not insoluble, and one or two plans have been suggested which appear to satisfy the required ends. It seems to have been established that voltaic electricity is, of all the means available for the purpose, the one which presents the greatest advantages. And the substitution for the old platinum wire fuze, of the Abel fuze, in which the electric spark is generated by the interrupted passage of the current through a priming material of subsulphide of copper, subphosphide of copper, and chlorate of potassa, permits of the use of electric batteries which were before inapplicable, and of the explosion of torpedoes with perfect certainty at distances before unattainable. Indeed, the introduction of this fuze has rendered possible the development of torpedo science which has now been attained. The batteries may be of the simplest character, and a very efficient one can be readily extemporized with a piece of hard timber, a little zinc and copper sheet, an old blanket, some vinegar and common salt. A battery of this sort, weighing only 25 lbs. and about 7½ in. square, will remain in good action for at least twenty-four hours, and can be easily cleaned and recharged. Such a battery, from its small size, weight, and great simplicity, is especially well adapted for boat operations.

The explosive agent to be employed in

torpedoes may be gunpowder, nitro-glycerine, or gun-cotton. Of these, gun-cotton is on many accounts preferred; and since the recent discoveries as to the susceptibility of gun-cotton to explosion by concussive effect, and the great resulting increase of power, its normal advantages have become more decided. There still remain a vast number of points, such as the nature of case or envelope to be employed; its thickness; the depth to which the torpedo should be sunk; the positions in which it should be fixed; the proximity of one torpedo to another; the the size, form, &c. The bare enumeration of these points will suffice to indicate that the subject is one which admits of an immense deal of working out, and will, perhaps, account for the length of time occupied in its investigation.

As to the practical value of torpedoes we have furnished some illustrations. But, in truth, it is unnecessary to multiply illustrations, for the value of these instruments may almost be regarded as self-evident. There are two points in every ship absolutely unprotected—the deck and the bottom. Of these the torpedo attacks one—the bottom. And it is a question if any ship can ever be made so strong as to resist the effect of a powerful submarine mine exploding directly under it. The use of torpedoes is not limited to serving as auxiliaries to forts, or as a means of keeping vessels under the fire of batteries. They are useful also on their own account, as a means of defending positions independently on a coast or in small channels and rivers which are quite unprovided with defensive works. Their invisibility forms another element of their importance, to which we may add their comparatively small cost and ready applicability to almost all positions. But it is necessary to guard against the impression that torpedoes are destined to supersede other and more old established means of defense, as ships and forts and guns. Invaluable as auxiliaries, and even as independent means of defense, their value is limited by two considerations. In the first place, the sphere of action of a torpedo is small; as compared with that of a fort or ship, exceedingly small; and an attacking vessel is safe as long as it contrives or chances to keep outside that area of destructive effect. In the second place, no torpedo can act more than once, and when it has exploded, the area of water which it guarded becomes defenseless. But with these limitations, their value can hardly be over-estimated; and it is satisfactory to know that the subject has been thoroughly and practically considered, and that we possess on paper at any rate a scheme for their use so complete as to relieve us from all anxiety on this score. It would, however, be more satisfactory still to know something definite as to the recommendations of the committee, and we hope that some member will think proper to ask in the House for such portions of the report as can be discreetly made public.

THE STABILITY OF FLOATING DOCKS.

From a paper on the Iron Floating Dock of Carthagena, its proportions and relative stability, read by GEORGE B. RENNIE, M.I.C.E., before the Institution of Naval Architects.

The form of this dock may be briefly described as an oblong rectangular box or trough, without a top or ends, the walls and bottoms of which are hollow, and divided into several independent chambers. The vessel to be docked is placed between the side walls, and is raised completely out of the water by the buoyancy of the bottom of the dock. The side walls act as floats to prevent the dock sinking too rapidly, and eventually from being entirely submerged.

The operation is performed in this way, water is allowed to flow into the different compartments forming the base, by means of sluices, and distributing pipes; the dock then gradually sinks, until the buoyancy of the chambers, forming the side walls, becomes equal to the weight of the entire structure; that is, when it is desired to sink the dock to its greatest depth for the purpose of taking in the deepest draught ship the dock is intended for, for vessels of less draught it is only allowed to sink to a depth sufficient for the particular vessel. The vessel is then hauled in between the walls, and the engines and pumps of the dock set to work to discharge the water from the bottom or base; when empty, it is capable of sustaining a weight of ship (less the weight of the dock), equal to the total displacement of the bottom or base. The vessel is shored up in the usual manner adopted in the ordinary graving dock.

The dock is entirely of iron, with the exception of the decks, shoring steps or altars and fenders, which are of timber. It is strengthened both longitudinally and transversely by bulkheads, which form the divisions of the chambers, as well as by in-

termediate lattice framing, which give the structure great stiffness.

The dock for Carthagena was commenced in 1859, sent out in pieces from England, and erected at Carthagena in a shallow basin prepared for the purpose, and when completed water was let into the basin and the dock floated out. When first floated, it was found to have an uniform draught of water of 4 ft. 7 in.; this gives a total displacement of 4,400 tons of sea water, which is equal to the weight of the dock complete.

Some of the largest vessels which it has raised are the frigate Princessa de Asturias, of 3,810 tons, and 21 ft. draught of water, the frigate Villa de Madrid, of 27 ft. 6 in. draught, weight unknown, the ironclad Sarragoza, of 4,972 tons, and 25 feet draught, and the ironclad ship Numancia, of 5,600 tons weight, and 24 ft. 1 inch draught, this latter vessel remained supported for eighty days, without causing any damage to or undue straining of the dock. The weight of this ship was further tested by the depth of flotation of the dock as observed with the ship on it; this was ascertained to be 11 ft. 3 in., giving a total displacement of 10,800 tons of sea water; but on examination of the different chambers it was found that there was about 7½ in. depth of water in the lower ones and 7¼ in. in the middle ones, equivalent to 800 tons weight; this added to the weight of the docks, 4,400 tons, gives 5,200 tons, leaving 5,600 tons as the weight of the ship. The dimensions of the Numancia, the largest of the above named vessels, are as follows: length (perpendicular), 316 ft.; extreme breadth, 57 ft.; displacement at load draught, 7,420 tons.

The dimensions of the dock are as follows; length, 320 ft.; breadth outside, 105 ft.; ditto inside, 79 ft.; height outside, 48 ft.; ditto inside, 36 ft. 6 in.

If the few inches of water remaining in the base and middle chambers were entirely removed, the draught of water of the Carthagena Dock, with such a vessel as the Numancia, of 5,600 tons weight, would be 10 ft. 6 in.

The main proportions of the dock are as follows; the length is between 3 and 3¼ times the breadth. The width between the walls at the top is ¾ of the breadth. The floor of the dock is ½ the breadth. The height of the side walls is somewhat under ⅓ the breadth. The depth of immersion 1-10th of the breadth. These proportions are suitable for almost all sizes of floating docks of the rectangular form. Thus, supposing a dock to be made capable of lifting and sustaining a vessel like the Achilles, of say 10,000 tons weight. the breadth would be 120 ft., the length 400 ft., the width inside 90 ft., the "floor" 60 ft. in width, and the immersion 12 ft.; total displacement 16,457 tons.

In calculating the height of the metacenter, or the greatest height the weights may be raised above the center of displacement of the immersed body at an angle of inclination, say of 10 deg.; and taking the distance between the centers of gravity of the immersed and emersed portions due to the inclination at two-thirds the total breadth, and multiplying by the portion immersed, and dividing by the total volume immersed into the sine of the angle of inclination, it will give 90.75 ft. for the distance of metacenter from the center of gravity of the volume immersed, or 85.5 ft. above the line of flotation for the Carthagena dock, whereas the center of gravity of the entire structure and ship is calculated to be only 18 ft. above the line of flotation, allowing for a ship of 26 ft. 6 in. draught of water on keel blocks 4 feet in height.

In the dock proposed, the metacenter, is 101.5 ft. above the center of gravity of displacement, or 95.5 ft. above the line of flotation, and the centre of gravity of the dock with the Achilles, is calculated to be only 19 ft. 3 in. above the line of flotation.

In calculating the amount of statical stability of the dock at Carthagena with an immersion due to the weight of such a vessel as the Numancia, of 5,600 tons, it is found that supposing the inclination to be 10 deg., that the moment of stability will be 360 when reduced to feet and tons per foot in length of the dock, or a total of 118,080 tons for 320 ft.; and the dock proposed would have a moment of stability of 549.2 when reduced to feet and tons per foot in length, or a total of 219,680 tons for 400 ft. This is nearly as the cube of the breadth, and directly as the length.

Comparing this latter with a dock of a U-shaped section, with water ballast, like that actually made for Bermuda, as calculated from a lithographic drawing, giving the particulars of this dock, it is found that the moment of stability equals 660 foot-tons per foot in length, or for the length of 333 ft., a total of 219,780 ft.-tons, or about the same as the one proposed, of a rectangular form.

A further comparison of the dimensions, weight of ship to be docked, height of metacenter of these two forms of docks, may not be without interest:

	U-shaped Section.	Rectangular Section.
Available length of dock for the largest ship....	333 ft.	400 ft.
Extreme outside breadth..	123 ft. 9 in.	120 ft.
Extreme inside breadth...	85 ft.	90 ft.
Breadth of "floor".....	50 ft.	60 ft.
Draught of water with heaviest ship.	40 ft.	12 ft.
Area of immersed section ditto.....	4,000 sq. ft.	1,440 tons.
Greatest weight of ship capable of being docked	8,000 tons.	10,000 tons.
Weight of dock.....	8,350 tons.	6,475 tons.
Center of displacement below line of flotation.	18 ft.	6 ft.
Distance of metacenter from center of displacement.....	38 ft. 6 in.	101 ft. 6 in.
Distance of center of gravity from center of displacement.....	5 ft.	25.3 ft.
Centre of gravity above or below line of flotation.	13 ft. 3 in. below.	19 ft. above.
Moment of stability per foot in length of dock..	660 tons.	549.2 tons.
Total for whole length of dock.....	219,780tons.	219,680 tons.
Draught of water to take in a ship of 26 feet draught with keel blocks 4 feet in length.....	50 ft.	45 ft.

From the above comparison, it will be seen that a dock of rectangular form of the same proportion as that of Carthagena, will have the same total stability as the U form of dock, require about one-fifth less material for its construction, and be capable of supporting a longer ship of one-quarter greater weight, and with less draught of water. Moreover, the arrangements for docking are less complicated; for when the ship is once on the keel blocks, pumping is the only operation to be performed, as there are neither gates nor caissons to close in the ends.

To represent the relative stability of different forms of section in a clear and simple manner (although not so accurately as may be found geometrically or mathematically), the following table is compiled from experiments on different sections made of thin copper, to a scale of 10 ft. to the inch. The models were all 9 in. long; the leverage was taken at 8 in. from the central line of the model.

The lead weights representing the ship were cylindrical, and supported on their axis, at a distance representing the height of the center of gravity of the ship, above the floor of the dock of 27 ft. 6 in.

In the table, A and B represent sections of docks, of the form proposed and that actually executed. It will be seen on comparing the inclination of these two forms with the same weight and leverage, that B, the U shape, gives greater stability per unit of length than A the ⌊⌋ shape, but as the model U was made by mistake to represent 127 ft. 6 in. in breadth instead of 123 ft. 9 in., the relative stability as shown by the angle of inclination is somewhat greater than calculation indicates.

The model C shows how the stability of the same form of section may be increased, by the addition of water ballast at the bottom.

The model D, segmental form, may, with the addition of water ballast, have nearly a stability equivalent to the form A.

The model E represents the Carthagena dock, with its angles of inclination, and with the same weight and leverage as the other models.

Although it may be seen from this that other forms may have a stability equivalent to that of the rectangular or flat form, it can only be done by the addition of a considerable amount of water ballast, which so increases the draught of the dock as to necessitate the ends being closed in.

The Carthagena dock, as before mentioned, was sent out from this country in pieces, and erected in a shallow basin made for that purpose, at Carthagena; this on the whole (when practicable) seems the most safe and simple plan, and the basin is moreover available when required for taking in the floating dock for the purpose of cleaning, painting, or repairing.

Wooden floating docks of somewhat similar section to that of Carthagena have been towed to their place of destination, as was the Pola dock, from Venice, the Havanna dock, from New Orleans, and more recently, that of Alexandria, from the south of France, but the square ends of this form are no doubt ill adapted for being towed through the water.

In order to meet this difficulty, when it was contemplated to tow a dock across the Atlantic, a modified arrangement of the rectangular form was proposed by Messrs. Rennie, better adapted for being towed through the water. The side walls were to be reduced to about two-thirds of the length of the floor of the dock, the rectangular ends of the floor to have been rounded off so as to form pointed ends, upon which temporary

sides were to be raised to the required height, in order that the dock might be decked over from end to end; this deck, together with the temporary sides, would have to be removed on arrival at its destination.

Considering the length of the voyage, it was thought that the empty space below the deck might be available for the stowage of coals and other stores to supply (during the voyage, the steamers employed to tow the dock out. This form of dock would not have required a basin as at Carthagena, and the necessary repairs could have been effected by means of a rectangular iron box lowered under the dock, and placed against the defective part, and the water pumped out from within it. The joints between the box and the bottom of the dock being previously made water-tight by means of an elastic substance, or the water kept out by a pressure of air, which, in this case, would not have exceeded 3 lb. per square inch.

In conclusion, it is considered that floating docks of the form and proportions to that of Carthagena will have ample stability for the heaviest ship to be docked.

That it is of the simplest construction.

That the smallest amount of material for a given strength and stiffness will be used in its construction.

That the cost will be less than for other forms of section.

That the simplest docking arrangements and safety of the dock are best attained by that form.

And lastly, that by the modification suggested in the paper, they may be towed with comparative safety to any part of the world.

A Table of Experiments on the Stability of different Sections of floating Docks, made on Copper Models. Scale of 10 ft. = 1 in.

Form of Section.	Weight of model in ounces.	Weight representing ship in ounces.	Approximate proportion of dock to ship.	Breadth of model to scale in feet.	Height of center of gravity of ship from floor to scale in feet.	Degree of inclination with weights, at a leverage of 8 in.			
						1 oz.	2 oz.	4 oz.	8 oz.
				ft. in.	ft. in.	deg. m.	deg. m.	deg. m.	deg. m.
A ⌊‾⌋	....	....	....	.....	.....	0 35	1 29	3 2	7 7
	48½	49½	1:1	120 0	27 6	0 52	2 11	3 57	9 6
	....	73½	3:2	.....	.....	1 29	2 35	4 35	10 6
B U	....	....	....	.....	.....	0 31	1 12	3 49	5 50
	42	49½	1:1	127 6	27 6	0 24	0 59	3 26	5 36
With water ballast	....	73½	5:3	.....	.....	0 21	0 55	3 6	4 14
C ⌊‾⌋	....	....	....	.....	.....	0 55	1 29	3 53	8 22
Without water ballast	....	94½	1:1	.....	.....	0 58	1 57	5 9	10 6
Without water ballast	48½	73½	3:2	120 0	27 6	1 57	3 5	5 43	12 8
With water ballast	....	....	....	.....	.....	0 52	1 26	2 45	6 28
With water ballast	.	49½	1:1	.....	.....	1 16	2 7	3 22	8 18
With water ballast	....	73½	3:2	.....	.....	1 57	3 9	4 45	9 19
D ⌣	....	....	....	.....	....	3 43	6 51	14 34	
Without water ballast	....	73½	3:2	.....	.....	2 28	3 53	7 28	
With water ballast	48½	....	....	120 0	27 6	1 43	3 23	7 24	14 2
With water ballast	....	49½	1:1	.....	.....	1 23	2 27	5 9	10 2
With water ballast	....	73½	3:2	.... .	.....	1 23	2 51	5 36	10 32
E ⌊‾⌋	....	....	...f	.....	.....	0 31	1 33	3 37	8 5
do	30½	49½	5:3	105 0	27 5	1 26	2 35	5 43	12 15
do	....	73½	7:3	.....	.....	2 11	3 2	7 7	14 48
F U with water ballast	....	....	....	.....	.....	6 22	12 48		
	32	49½	5:3	80 0	27 5	9 19	14 52		
	....	73½	7:3	.....	.....	7 14	12 31		

THE CENTRAL RAIL SYSTEM.

ABSTRACT OF REMARKS BEFORE THE SOCIETY OF FRENCH CIVIL ENGINEERS.

From the "Compte Rendu des Séances." Translated from "Annales du Génie Civil."

For some years the development of railways has gradually given rise to a new problem for engineers, viz: the construction of engines capable of overcoming heavy grades without involving any considerable change in the present systems of *exploitation*. At first, inclined planes were used, up which the trains were drawn by cables; then the Engerth engines, and engines constructed for the Northern railway, &c.; latterly, the funicular system of M. Agudio, and finally, the Fell engine, working upon a central rail, as proposed by Baron Seguier. A similar engine was discussed by M. de Landsèe, before the Society of Civil Engineers at their last session in November. He remarked that the experiment of crossing Mont Cenis had been favorable to the central rail, which permitted the ascent of grades hitherto unused in railways. The engines, through the supplementary adhesion obtained by means of a group of horizontal wheels upon a median rail, have a tractive force equal to at least twice the weight of the engine. He has laid down the principle, in the plan which he has developed, that the engine for the central rail should be able to operate upon an ordinary road at certain points. This condition seemed necessary to him in order that its work may be done easily and conveniently. He accordingly supposes the median rail to be absent at switches, on bridges and at all parts of the road where the grade is easy enough to dispense with it. The locomotives should be adapted to ascend grades of 70 millimeters per meter (369.6 feet per mile), with curves of 50 to 60 meters radius. The type of engine which seemed to him best suited to the case was that having four coupled wheels. The proposed engine weighs 25,000 kilog. without load, and 26,000 kilog. loaded (28 or 30 tons), each axle sustaining 13,400 kilog—a moderate load for steel rails. According to the tables of M. Vuillemin, this engine, on a horizontal track, could draw 400 tons, but in a mountainous country such a load would be excessive, the maximum being 130 tons, and M. de Landsèe has calculated that for trains of 125 and 85 tons, this engine can ascend grades with the following velocities, &c.:

Velocity in kilomet. per hour.	Velocity in miles per hour.	Supplementary adhesion in tons.	Train 125 tons grade.		Train 85 tons grade.	
			Millim.	Feet pr mile.	Millim.	Feet pr mile.
20	12.4	0.	16.8	88.7	24.3	128.3
14	9.	28.8	41.3	218.	58.2	307.3
10	6.2	30.	50.	264.	70.	369.6

M. de Landsèe shows, that for engines weighing 20 tons loaded, and 17.5 tons light, on a road 1.10 m. guage, a median rail will be necessary for a train of 60 tons when the grade exceeds 137.3 feet per mile; with a supplementary adhesion equal to the weight of the engine, grades of 322 ft. per mile are admissible; and reducing speed to 6.2 miles per hour, the inclination, with a maximum adhesion, may be 369.6 ft. per mile. With engines weighing but 10 tons, under the foregoing conditions, the weight of the train may still be 30 tons on a grade of 369.6 ft. per mile. Since it results, from the experiments of M. Forquenot, that the evaporating power of engines depends upon the rapidity of exhausts, and therefore upon the speed of the train, M. de Landsèe suggests the use of four cylinders, two to drive the vertical, and two the horizontal wheels; thus attaining 8.884 exhausts per second for an engine moving 12.4 miles per hour, with with wheels of .80 m. (2 ft. 8 in). In such a case, the boiler, in the ascent of a grade of 369.6 ft. per mile, will have but 87 sq. meters of heating surface at a pressure of 10 kilog. per sq. cent, with a back pressure of 1.50 kilog. per sq. cent. The two pairs of cylinders being independent of each other, the engine can be run without using the horizontal wheels. The coupling of the exterior and interior wheels is effected by the steam; for this purpose the movement of the valves is taken from the rear wheel and transmitted to the valves by means of two distinct levers. A relieving axle is common to the two pairs of cylinders. The admission of steam to each pair is controlled by a special regulator, allowing the starting or stopping of the horizontal wheels while the vertical ones are in full motion. The grip of the horizontal wheels is given by means of a lever at the command of the engineer, and a guage is provided which shows the amount of grip. The coupling is effected by means of two small bevel gears. The real object

of the coupling is not so much to transmit a great effort, as to ensure uniform motion and the passing of centers—each pair of wheels being controlled by one cylinder. Owing to the practicability of dispensing with the supplementary adhesion, this engine may be classified with other types in use, and can travel on any road in actual operation.

In answer to some remarks on the subject, M. de Landsèe observed, that a single distribution was employed merely for the purpose of simplifying the mechanism, but that nothing would prevent the use of separate distributions for each pair of cylinders.

PASSENGER STEAMSHIPS.

From "Engineering."

The gradual growth of science and experience has been attended with the most striking changes in the material, size, form, structure, machinery and working results of ocean passenger steamships. Where we had timber-built ships, all, or nearly all, are now built of iron; where the tonnage was once 1,000 tons, or so, it is now three times as much, or even more. Where the lines were once full, and the beam wide in proportion to the length, we now see sharp, fine, fore-and-aft bodies, and lengths of from eight to ten, and even eleven times the beam. The hulls, even when referring to iron ships only, have been greatly changed in structure; where only paddle engines were employed, screw engines are now almost universal; and where we once had but ten knots, we now have fourteen, with the same, if not an even less, consumption of fuel, although the difference in propelling work done represents a difference even greater than that between the cubes of these speeds, or that between 1,000 and 2,744.

It may be questioned whether naval art has not advanced more rapidly than any other branch of structural and mechanical science, and even admitting that it has, there still appears to be a wide field for its further progress. There are many reasons why passenger steamships should undergo further changes as radical as those so well known to be going on in the navy, and it may happen, and that at no distant time, that masts, spars and sails will be dispensed with altogether, as indeed, for very fast steaming, they must be, inasmuch as, at high speeds, the point is soon reached where sails, instead of aiding, only retard the progress of a ship.

Apart from questions of masting and rigging, it is possible also that a great change may take place in the size and form of passenger steamships. For the same displacement longer, wider and shallower ships seem desirable. It is not depth, or great draught of water, that is wanted in passenger vessels, but deck room, and, generally, open-space and light. These are the great requisites for ocean passenger traffic. For convenience of comparison merely, we may suppose two vessels of rectangular form; in other words, they shall be rectangular boxes. Each shall have a length equal to eight times the beam. Let one be 320 ft. long, 40 ft. beam, and draw 20 ft. of water, thus displacing 7,314 tons, and presenting 27,200 square feet of bottom, side and end surface, or skin, under water. The area of immersed midship section would be 800 square feet.

Another ship, having the same displacement, might be made 403 ft. long, 50.4 ft. wide, and 12.6 ft. deep. Its "skin," or under water surface, would be 31,752 sq. ft. in extent, but its midship section would be only 635 square feet in extent. Its deck area would be 20,320 square feet, or nearly half an acre, as against 12,800 square feet on the other and deeper vessel. This comparison refers, for convenience only, to rectangular boxes, but in both cases the vessels are eight beams in length, and the same proportions of deck area, frictional surface, and midship section would hold good when these boxes were hewed to the forms of fast steaming ocean ships. In plan, the lines, excepting only in scale, would be identical in both, the difference being only in the transverse section. The longer and wider ship would have a greater superficial extent of hull and deck, and, consequently, a heavier hull, but, possibly, she might have one deck less than the shorter, narrower and deeper ship. The longer ship would also, perhaps, require additional stiffening to compensate for her shallowness, not so much with reference to her riding the waves, but for her strength in the event of taking the ground or going upon a rock. She would, in any case, be much the roomer and easier passenger ship, and it is a question whether she would not require less power to drive her. The elements of this question appear to be well within grasp.

It has been the fashion among many naval architects of late years to attribute the greater portion of the resistances to vessels driven through the water to skin friction. Yet our two imaginary rectangular boxes, moving at 14 knots an hour, or 23.6 ft. per

second (and as for this matter they need only have a rectangular midship section), displace respectively 540 tons and 428 tons of water per second. This water must absolutely be moved out of the way, and the power expended in putting it into motion varies according to the form of the ship, with the fineness of the lines at and below the water level. All ships must displace their own weight of water in running from about one-half to three-quarters of their own length, according to the fineness of their lines. If the average velocity given to the water be computed, as it may be, with some pains, at each successive depth of, say, a foot of draught, the power expended on this work alone may be readily calculated, and it will in all cases be found to form a very large, or let us say the larger, portion of the total power actually and effectively exerted in propulsion, this power being, on the average, but about two-thirds of the indicated power of the engines. It is, of course, supposed that the ship is all the time in hydrostatic equilibrium at both ends, the water running in at the stern and under the quarters exactly as fast as it displaced at the bows—and the mistake must not be made of supposing that the influent water compensates, in the least degree, for the loss of power in forcing aside the water in front. In this comparison, the longer, wider, and shallower ship, having but 635 square feet of midship section, would have the advantage over the shorter, narrower, and deeper ship of 800 square feet of midship section, the difference being in the exact ratio of the midship sections themselves. On the other hand, however, the longer ship would have a wetted surface almost exactly one-sixth greater than the shorter ship. Hydraulic friction is independent of pressure or head of water, being the same per square foot at the same velocity at all depths. Colonel Beaufoy found the skin friction of each square foot of painted wood to be 1.3 lb. at 13 knots an hour, and, according to his experiments (although they were made some seventy years ago, and possibly under circumstances of error of observation), he found the friction to increase in a proportion less than as the squares of the velocities. Applied to the case of steam vessels, it is demonstrable that skin friction, except in very long, very fine, and very shallow vessels does not form the principal resistance to motion. And in the cases of the two vessels already supposed, the somewhat greater skin friction of the longer ship would be much more than compensated by its lesser midship section, requiring proportionately less power to drive it (the lines being the same) at a given speed. Which of the two vessels would be the roomier, lighter, and more airy, as well as drier and easier in a sea way, we need not stop to discuss, although the subject is one to which we shall return.

THE ÆSTHETICS OF CONSTRUCTION.

From a paper read before the Liverpool Architectural Society, by Mr. G. F. Deacon, C. E.

The subject of this paper is the consideration of the conditions under which we are pleasurably impressed by the presence, in our structures, of those natural laws with which we have become familiar, in a greater degree perhaps than we are prepared to believe, by the senses of sight and touch; and not of necessity by that higher mental power which analyzes mathematically the action of these laws. I only speak of the absence of mathematical analysis in the minds of those for whom we build, and do not by any means suggest its exclusion from the minds of the builders. I have always believed that the distinction between the professions of the architect and the engineer is, or ought to be a distinction rather of degree than of kind. We are both of us constructors. We must investigate in common the resistance of materials to the simple strains; those, for instance, of compression, shearing, and tension; and we must, to become masters of our subject, be conversant, though perhaps in a different degree, with the more complex calculations arising from the combination of such strains, either in the same piece of a structure, or in pieces depending for their support upon one another. We must both of us consider, without prejudice, these elements in the works of eminent men who have preceded us, not with a view to servile imitation, but as a safe and well-tried foundation upon which to erect original, and it is to be hoped, better works of our own.

This cursory glance at the minimum amount of scientific knowledge which it appears to me we ought to possess in common, suggests the consideration of that particular branch of æsthetics included under the general term *decoration*, which is altogether independent of construction, and which is excluded from the more immediate subject of this paper.

Our scientific speculations, which are themselves subservient to the adaptability

of the result to the end in view, having brought the design in which we are engaged to a certain point, we must, in carrying out our enterprise, and without in any way hiding the work produced by our reasoning faculties, exercise in a greater or less degree our imaginative faculties; often for the purpose of adding pleasing outline or relief, always with a view to the development of that intrinsic beauty which, as I hope to show, is rarely absent from scientifically designed structures.

Agreeable sensations arise in our minds from the contemplation of the beautiful in nature and the beautiful in art, from two distinctly different causes; the one depending solely upon our appreciation of the action of the mechanical forces of nature, the other affecting our senses in virtue of certain distributions of form, color, or light and shade, for which we can lay down but few rules, and those of a merely empirical nature.

Take in your hand a frond of the common lady-fern. It has, for some reason, a most pleasing effect on the eye, and you call it beautiful. Paste the same frond on a sheet of paper in a vertical position, and to most minds more than half its beauty will have vanished. And why? On the first impulse one would be inclined to answer, "because it formerly hung in a beautiful curve, and we have now rendered it rigid and straight;" but a little consideration will show the incompleteness of such a reply. The circle is a beautiful curve, so is the spiral, so is the cycloid; but the fern, when bent into any of these, will have but little more beauty than it had as a straight line. Only one curve will answer the purpose, and that is the curve into which it naturally falls, the curve in which the force of gravity is exactly balanced by the resistance of the stalk to flexure.

Innumerable examples of a similar nature might be adduced, and I think they would one and all show, "that there is a pleasurable effect produced upon the mind by forms resulting from, or balanced by, the direct action of the mechanical forces of nature, when those forces act in a manner which we apprehend intuitively, and are not complicated in their mode of producing their effect upon the senses by artifical means, or by the superimposition of one upon another." And this result is evidently altogether independent of the arrangement of the component parts—a division of the subject to which I have already alluded, as including all embellishments not necessary to those conditions of stability which the ordinary mind is capable of appreciating, but which may nevertheless be introduced to enhance the beauty of the structure.

The first of these effects appears to have a peculiar interest for the engineer, as it is the basis of a great problem; namely, how he is to produce, in those works which are pre-eminently dependent for beauty, on their lines of construction, such forms as the mind will at once apprehend as curves natural to the conditions involved, and which it will not be slow to call beautiful; in short, such curves as are known by engineers as lines of equilibrium. The second, or decorative effect, it is the more immediate object of the artist to produce, and in all cases it should be subordinate and subsidiary to the first.

For the purpose of illustrating my statements, or, I would rather say, as the best arguments that I can adduce, I have collected engravings and photographs of a few of each type of designs for iron bridges executed or proposed; and I have numbered these types, not according to their scientific classification, but rather as they produce a pleasing effect, or the reverse.

Type 1. Box and plate girders.
" 2. Lattice girders.
" 3. Bowstring girders.
" 4. Arched ribs with braced spandrels.
" 5. Suspension-bridge with stiffening girders.
" 6. The continuous parabolic system.
" 7. Simple suspension-bridge with vertical rods.

If we consider for a moment the disagreeable impression produced upon us by the first of these types (and every Englishman has ample opportunities for considering it), we cannot fail to notice that it does not altogether arise from the monotonous oblong form, or even from the flat uninteresting face of the structure. Cover it with moldings and ornaments of cast iron—paint it in the best taste—decorate it as you will—you cannot redeem it from its uncompromising ugliness. And why? Because it appears to be out of place; it is a form which seems to want some additional support; it is essentially deceptive. We cannot appreciate the beauty of construction, the principles of which we do not instinctively comprehend. In a limited sense those principles are correct enough. In the molecular structure of

every straight beam there are curves of direct tension and compression, which clear up the mystery at once. The lines of compression are concave downwards, those of tension concave upwards. They cross each other in every case at right angles, and each cuts the neutral surface of the beam at an angle of 45°.

Although the two halves are in all respects similar, there are not two points in the half elevation of the web and flanges, at which the stress is at once the same in amount and direction. Along each individual curve the stress varies from center to end, and every curve represents an amount of stress differing from that of every other. Then what an infinitely complicated piece of workmanship we should have if we attempted to vary the section of our wrought iron plates, in proportion to the duty that each point in their elevation has to perform. Practically we cannot do this. It is for the engineer to determine how far he can approximate to the theoretical conditions involved, and thus save material without necessitating more labor than the value of that material represents; and in most cases this can be done with great advantage. In small wrought iron girders we may, perhaps, by due attention to the principles of stress, save fifteen per cent of the material necessary in a girder of equal strength, but of uniform section, and that without adding to the labor in the least. This percentage, however, is but a fraction of the weight which theoretical perfection represents as lost.

This type, then, is essentially bad in respect of its response to the theoretical conditions of a minimum weight of material. Nevertheless, in small spans the economy of labor consequent on simplicity of construction often compensates for this defect.

Type second is the straight lattice girder; and here the lines of stress are guided from their natural curves, and concentrated in the flanges and diagonals. This fact, however, does not assist the mind in conceiving the mode of action of the beam, and I am inclined to think that all the superiority of appearance is to be traced to the decorative effect produced by the open lattice work, and the reduction of apparent weight. Among the best known bridges of this class are, in England, those at Crumlin and Runcorn, and on the Continent those over the Rhine, at Cologne, and at Kehl, near Strasburg, and that over the Vistula at Dirschau. But one and all of these must be regarded as failures in an æsthetic sense. Probably Mr. Baker's towers at Runcorn, and the piers at Dirschau, are most in keeping with the works. The Gothic piers of the bridge at Kehl have a singular effect. Their appearance is very striking, but they do not harmonize well with the long horizontal lines of the girder, or with its lattice bars arranged at angles of 45°. The proximity of Strasburg Cathedral, too, is not calculated to impress one in favor of that puny cast iron architecture.

The bowstring girder is our next type, and it includes all those in which the top or bottom flange, or each, consists of a segmental or parabolic rib, connected together by diagonal lattice bars. The best known of those which have both flanges curved are Brunel's bridge at Saltash, and that over the Rhine at Mayence. All these structures are, as regards the iron work, more natural than either of the preceding types, and we must accord to them the merit of giving us the first clear idea of the manner in which they do their work. We may not feel satisfied with their appearance, but we must admit that it is, or may be made, much superior to that of either of the straight types.

We now come to the arch, respecting which I shall say more hereafter, but assuredly we cannot hesitate to assign to it, in our classification, a higher place than we would to those already mentioned. The mind at once perceives the natural and efficient manner in which it supports the load to which it is subject.

Our fifth type is the suspension bridge, stiffened in such a manner by lattice work as to be capable of bearing, without undue vibration, heavy rolling loads. It is sufficiently obvious that the effect of the simple parabolic or catenarian curve is, in a great measure, marred by the proportions of the stiffening girder.

In the late Paris Exhibition were exhibited two striking drawings, by Herr Carl von Ruppert, for bridges across the Bosphorus, and over one of the greatest chasms in the tertiary limestones of the Balkan. In carrying out the Austrian project of a railway to Asia Minor, it will be necessary to cross these places, and Von Ruppert has probably solved the difficulty in a very complete manner. It is well to mention that his investigations have been published, and they can leave no doubt in the mind of the reader that the Austrian engineer has brought together principles already well

understood, with a boldness and originality resulting in a complete success.

There is but one more, and that is the pure suspension bridge. We cannot improve upon that simple catenary. Its mode of action is apparent at a glance, and its curve is evidently a natural one. But, unfortunately, we have no means of rendering it sufficiently rigid for railway purposes, without destroying its chief æsthetic characteristics.

Thus far I have endeavored to lead you through the general principles, in virtue of which each of the seven types supports its load. You may feel inclined to change the order of one or two, but that will not affect the general result.

Had I based the classification upon the relative economy of material, upon the absolute weight of the superstructure which each would have required for the same span, and to bear the same moving load, it is at least gratifying to know that the arrangment would have been precisely the same, and that, although in small spans the order of ultimate economy is somewhat changed by the different proportions of labor to material required, it would not be felt in the large spans.

These general facts have been long known to the engineer; but Mr. Benjamin Baker has recently reduced them to approximately correct figures for different lengths of railway bridges up to the limiting spans, and I have prepared, from his investigations, the annexed table, showing the weights of material in spans of 700 ft., and also in spans 100 ft. less than the limiting spans. The types are in principle the same as those I have described, though not arranged quite as Mr. Baker classed them.

I have now laid before you the general arguments which, you will probably admit, prove, at least in regard to great bridges, the truth of the statement that, in equal spans, the æsthetic properties of the lines of the structure vary in direct proportion to the simplicity of the design, in a scientific sense, and in the inverse ratio of its actual cost.

These results are sufficiently remarkable; and if we can in every case find beauty and science walking hand in hand, as here, shall we not be able to do more in the cause of both than we do at present? And this, I think, we can find in our works of stone and brick, without either the conditions of great size, or the cost of extra labor.

Table compiled from Mr. Baker's Analysis, showing the Approximate Weights of Wrought Iron or Steel in the Superstructure of Railway Bridges of six different types; the working stress of the iron being taken at 4 tons, and that of the steel at 6½ tons per square inch of sectional area:

Description.	700 ft. Span. Approximate weight in tons.		Limiting Span minus 100 ft.	
	Iron.	Steel.	Weight of steel in tons.	Length of Span in feet.
Box girder	51,030	.....	.....	.....
Lattice girder	17,360	4,410	27,315	900
Bowstring girder	6,650	2,780	68,055	1,300
Arched ribs with braced spandrels	3,500	1,995	364,420	1,900
Suspension with stiffening girder	3,045	1,715	276,450	1,900
Continuous girder with varying depth*	2,660	1,820	1,120,000	3,200

THE CORROSION OF BOILERS.

By Norman W. Wheeler.

The writer is induced to put forward a few crude thoughts in the hope that some competent chemist will experimentally determine whether his surmises are correct or otherwise.

The corrosion of boilers worked in connection with surface condensers is in great part attributed to a galvanic action induced by the condenser. But galvanic action does not establish itself spontaneously; some sort of chemical decomposition, or degradation of metals or other bodies being, so far as we know, a condition precedent, so that it becomes a question whether the corrosion observed is not the cause rather than the effect of the galvanic excitation observed.

When water is repeatedly vaporized and

* This type is nearly equivalent to Von Ruppert's system.

condensed, with very little exposure to the atmosphere, as is the case in practice, it becomes to a great degree deærated, but the question as to which of the numerous gases existing in natural water is first eliminated remains unanswered. If those gases, of which water absorbs the greatest bulk, cling to it with the greatest tenacity, a considerable part of the destructive effect is thereby accounted for. It is stated by good authorities that water absorbs at common temperatures its own bulk of carbonic acid, one twenty-fifth its bulk of oxygen, and still less of nitrogen. If, when water is deærated by heating, the neutral gas nitrogen is first expelled, the corrosive power of the water should be exalted by its atmosphere, so to speak, of carbonic acid and oxygen; and if, during the exposure to the air in the air pump and hot well, the water absorbs the gases in ratio of their supposed affinities, we should have in the boiler a pretty active solution of carbonic acid in oxygenized water, from which we ought to expect corrosion of the metal of lowest chemical rank exposed to its power, corresponding with the observed facts.

A case encouraging the belief in the seriate elimination and absorption of gases, occurred in the writer's practice in 1864. Four vessels were built for the Government, with return flue boilers and "high pressure" engines, but the steam was condensed, for the sake of fresh feed water, in open surface condensers; that is, condensers making no vacuum, but fitted with tubes and circulating pumps, and the steam spaces in the condensers communicating with the atmosphere through pipes. The condenser tubes were made of iron and galvanized, for the purpose of avoiding the corrosion of the boilers. The feed-water was drawn by the feed-pumps directly from the condensers. As a matter of convenience, the atmospheric pipes were led from the condensers and opened into the smoke pipes, so that when an exhaust took place, the vapor was for an instant driven out through the atmospheric pipe, and because of the continuous condensation, the gases in the smoke pipe were drawn back toward or into the condenser between the successive exhausts, thus keeping up a pulsation and swaying back and forth of vapor and gases in the atmospheric pipes, which, although made of copper, were eaten into holes in a few days. The pipes passed overhead through the fire rooms, and the continual dripping of hot water made those places very uncomfortable. The corrosion of the boilers was marked and unmistakable within a month.

The atmospheric pipes were then changed and led to the open air, and the corrosion of both boilers and pipes apparently ceased, and was not again observed while the vessels were within the range of the writer's observation.

It is supposed that carbonic acid was absorbed rapidly by the vapor and condensed water in the atmospheric pipes, the supply being derived from the gases of combustion, and the acidulated water passed into the boilers by the feed pumps.

Now, if it be proven that the water, while exposed in the hot well of an ordinary engine, absorbs oxygen and separates it from the nitrogen of the air, and that the nascent carbon of the oils, used to lubricate the internal parts of the engine, is seized by the oxygen when the oils are decomposed by the heat of the steam, we shall be able to account for an amount of carbonic acid in the boilers working in connection with common surface condensers, sufficient to destroy them rapidly.

WIRE ROADS.

From "The Engineer."

The great defect of the modern railway is, that the system does not admit of general use. It is true that a railway can be laid down and worked by locomotive power in almost any conceivable country, provided there is sufficient capital available for its construction, and sufficient traffic to pay for working it. But thousands of cases will present themselves to the engineer in which, although a fair amount of traffic may be expected, it is morally certain that this traffic could under no possible circumstances prove remunerative, for the simple reason that the capital expended would of necessity be out of all proportion to the money received for the carriage of goods or the conveyance of passengers. As we cheapen railways we increase their sphere of usefulness; and were it possible to reduce the cost of railways below that of common roads, and to render the conditions of working such, that on them, as on a canal, private individuals could run private vehicles, it is more than probable that common roads would cease to have existence, their place being taken by tramways or public railroads. Numerous attempts have been made to reduce the cost of rail-

roads, but with, for obvious reasons, very little success. The cheapest single line of 4 ft. 8½ in. gauge, which it is possible to lay in an easy country will cost, at least, £3,000 per mile. If the country is difficult or hilly, the expense of construction may very well rise to ten times the sum. Railways represent the most perfect mode of transit yet produced in one sense, and it is therefore to be regretted that they are not more generally applicable to all the purposes of locomotion than is at present the case; but it is, we think, still more to be regretted that there is no prospect whatever that they will ever become much more useful than they are now. A good deal remains to be done as regards tramways, which partake intimately of the nature of railways without being railways in the truest or highest sense. But even when tramways have received that enormous development of which the system is probably capable, conditions will still constantly exist under which it will be impossible to resort to their use; and the same truth applies to the ordinary macadamized or graveled road. Stretching a point, every ordinary highway and parish road may be regarded as the substructure for a tramway. No tram can be laid on a substructure much worse than our third and fourth-rate country-roads. Therefore it may be taken for granted that where a road can be made a tram may be laid, and also that where a road cannot be constructed no tramway can be laid down. But in almost every civilized or partially civilized country in the world, circumstances occur under which, though means of transit are required, it would be impossible to provide them, either in the shape of railroads, tramways, or common roads, at a price which would justify their construction even by a state, much less by any company of adventurers. Therefore it appears that the proposition with which we commenced this article applies to both tramways and common roads as well as to railways, though not with the same force; for both tramways and common roads are open to objections, which do not exist in the case of railroads, far more serious than the want of universal adaptability.

It has long been felt that some efficient means of transit, which might be used under any conceivable conditions, are badly wanted; but it does not appear that much had been done up to a very recent period to supply the want. The popular way out of such a difficulty as that, for example, which presents itself when the ore from an out-of-the-way mine has to be got to a seaport, lies in making a road, buying carts and horses, building stables, and hiring carters; where it happens—and in the colonies it does happen rather often—that no road fit for wheeled carriages can be made, the popular remedy fails of course. There are two substitutes for common roads; one consists of mules and the other of camels. Coolies and elephants we will leave out of the question for the present. Now mules are no doubt very useful, and so are camels; but any of our readers who has had to transport a 20-horse engine, for example, up country on the backs of mules or camels, will agree with us that, although the muleteer of song is a very picturesque creature, the muleteer of fact is, though picturesque, something else as well; and, making the best of mules and camels and their drivers, the great fact still remains, that they carry things slowly, and cost a great deal. In a word, mules and camels no more solve the problem of transport in distant lands, as English capitalists and engineers would have it solved, than a trained hippopotamus, weighing about four tons, and carrying a couple of Kaffirs, represents a perfect means of ordinary locomotion. It would not be easy to estimate the loss which accrues each year to our colonies as a consequence of the want of some means of bringing produce to market. There are coffee plantations in Ceylon, more than 40 per cent of the produce of which is constantly wasted and lost, simply because no efficient means exist of getting the coffee to market down the jungle-clothed sides of hills. The waste and loss of cotton in India, for the same reason, is enormous. In Namaqua land, again, there are valuable mines which cannot be worked because coal costs £8 per ton—half this expense, or more, being incurred in transporting it a few miles up the country on the backs of mules. It is impossible to estimate, indeed, at this moment, how much wealth is lost to the world because no means exist of transporting cotton, and coffee, and ores, and coal, over moderate distances at moderate rates.

Impressed as we are with the importance of this loss, and desiring as we do to see the loss for ever done away with, we have carefully watched every attempt that has been made of recent years to overcome the difficulty. The narrow gauge railways of Queensland; Mr. Brunlees' cheap lines in

South America; the pneumatic dispatch—in which there is more as a means of cheap transit in difficult countries than is at present perceived—these things, and such as these, holding out promise of future good, have all claimed our attention; but very little observation is sufficient to show that they none of them comply with the conditions of the greatest difficulty. Take the case of a coffee plantation in a fertile district on the side of a hill; between it and the nearest port, or the nearest road to a port, lies an impenetrable jungle, deep ravines, and water courses now dry and anon filled with a foaming torrent; the railroad can do nothing for such a case, the pneumatic dispatch is of as little value. What the planter wants is the wings of the dove to take him to the uttermost part of the sea. If he could but fly! If he could but organize a trained troop of flying steeds to take his produce bit by bit over the top of the jungle, across rock, ravine and torrent, then, indeed, the problem would be solved, and the flying steeds would serve a more useful purpose, and do more good than ever Pegasus has done yet.

Now, is this flight impossible? Are the difficulties to be encountered insurmountable? We think not. We have spoken of flying steeds, and we have done so with a purpose. It is evident that if we could construct a road above ground instead of resting on it, neither jungle nor forest need give us trouble. There is a race of pirates in Borneo who live in forests. These people seldom touch ground. Their roads consist of single trunks of trees felled, laid end to end, and carried on suitable uprights for miles through the depth of the forest from the sea shore. The jungle undergrowth is impassable, therefore those people make their road over it. We are all familiar with the rope bridge of South America, across which the traveler is drawn in a basket swinging below the bridge, which consists of a hide cable. In these two, the Borneo tree road and the South American bridge, we have the crude germ of an idea which, properly worked out, may do wonders for the good of mankind.

The only scientific development of the idea yet before the public is Mr. Hodgson's wire railway at Bardon Hill, Lecicester, already noticed in our pages.* This line, three miles long, extends from Messrs. Ellis and Everard's granite quarries at Markfield, to Bardon station on a branch of the Midland Railway. At Bardon is a tremendous rotatory crushing machine, capable of converting a couple of hundred tons or so of granite into road metal per day. We need not again describe the wire line put down to transport 100 tons of stone per day to this machine, but never as yet worked up to its full capacity. It will suffice to say that the principle involved consists in suspending a wire rope on wheels fixed to posts placed about thirty-one to the mile, just as are ordinary telegraph posts. The rope runs over a horizontal pulley of considerable diameter at one end, and at the other round a 4½ ft. Fowler's clip drum, driven by a 16-horse portable engine, which is not half loaded. One side of the six miles of endless rope is always traveling toward Markfield, the other side away from it, toward Bardon. The stone is loaded into boxes, which are hung on the rope and run full to Bardon, where they shunt off the rope, are emptied, and sent back to Markfield on the return line. The wire road winds in and out, passing here through a grove, there across pasture lands. In one place it jumps obliquely across the high road with a span of 600 ft. clear. The pace at which the buckets travel is about four miles an hour, the load in each about one cwt., and some thirty buckets come to the mile. The line has now worked for some months most successfully, and we are pleased to hear that in Italy, Spain, and Turkey the system is likely to be extensively adopted. The system is certain to prove infinitely valuable to countries perishing from that inanition due to want of means of internal circulation.

Here we have means of transport provided, by which all obstacles connected with the country are avoided. No doubt objections may be raised to the scheme, and difficulties are certain to be encountered in carrying it out on a large scale. One or two points, however, are certain; it has been proved that the principle can be applied in practice; wire-rope railways are very inexpensive—£150 to £500 per mile; they offer the only certain solution for hitherto insurmountable difficulties, and, lastly, the entire principle is correct. We did intend to speak of the mechanical questions involved, such as the best means of carrying the rope, putting on the buckets, the power consumed, etc.; but these we think best, after all, to speak of at a future

* See "The Engineer" for February 19, 1869.

time when the system shall have been more fully developed, and some inquiry shall have been made into its dynamics. So far the scheme is a mechanical success, and that is about the only point connected with it, save its all but universal applicability to the purposes of transport, with which we have anything to do.

RAISING WATER FROM MINES.

From "The Engineer."

In scarcely any department of the operations necessary to bring our subterranean treasures to the surface, is there greater diversity of comparative working cost than in the process of freeing the mines of water. The men who win our metals have made much more progress in this department than those who get our fossil fuel, as we shall presently see. Meanwhile let us get some idea of the financial significance of the subject by remembering that from the northern coalfield comprising Northumberland and Durham there has every year to be taken water fifteen times the weight of the output of the coal of the district, which, according to the the mines inspectors' last returns, reached, in 1867, a total of 26,500,000 tons. In Staffordshire the water raised is computed at ten times the weight of the coal; but the ratio of cost in each may be assumed to be alike. It is estimated at .343 pence per 1,000 gallons raised 100 ft., or, in other words, per million foot-pounds. This calculation is made upon the basis that the average of the lifts is 384 ft., which is computed to be the average depth of the pits in South Staffordshire; and this, for the purpose of calculation, may be taken as the depth in the northern field. Computed on the quantity of coal raised in 1865, the cost of pumping in the South Staffordshire collieries is estimated by Mr. E. B. Marten at £100,000 a-year, taking £500,000 as the capital employed, and allowing a 5 per cent reduction on this capital. The engines are presumed to work twenty-four hours per day. Taking Mr. Marten's figures for his guide, and adapting them to the 25,000,000 tons raised in the northern district in 1865, Mr. William Waller puts down the yearly cost of pumping the Northumberland and Durham district at £459,200.

How much more this is than need be, may not be accurately concluded, but may, to some slight extent, be imagined from a fact which Mr. Warington W. Smyth has placed upon record. It is that he has watched a large pumping engine in the north which raises water from 105 fathoms deep, in 12-in. lifts, at seven and a-half strokes per minute, with a consumption of twenty to twenty-five tons of slack per day, whilst a similar amount of work is done by a Cornish engine with from two to two and a-third tons. The coal was no doubt inferior in the former case, but the result, he intimates, shows that there are engines in the country consuming upwards of ten times the quantity of coal that is needed for the work accomplished. It is clear that the pumping at our coal mines is not conducted as cheaply as it ought to be, and we have reason to know that even the metal mines of Cornwall might be freed for less money than is now the current charge. What should be the cost of raising 1,000 gallons of water 100 ft.? Mr. Wm. Waller set himself to answer this question in a paper which he communicated to the North of England Mining Engineers during 1857. By the side of the figures as to the assumed average cost in the north of England and in South Staffordshire, he places data obtained under his own observations relating to waterworks. Should any one object that these are not parallel cases, he submits that the mining engine works under more advantageous circumstances; for this reason, that being necessarily in the first instance sufficient to reduce the water, afterwards in keeping it at the reduced level, it is working well within its power and under very economical conditions; whereas, the waterworks engine, having to contend with ever-varying demands, with extra and intermittent exertion, with increased friction and resistance in restricted pipe area, is under every disadvantage. For the purpose of comparison, however, colliery and waterworks engines may be considered as working under similar circumstances.

A most important difference in the duty of several engines in the same undertaking sometimes transpires. This is especially seen in the case of the East London Waterworks Company. It is stated on the authority of Mr. Wicksteed himself that the total cost of lifting a million foot-pounds, taken on the average of several years with different engines is: Single-acting engine, Boulton and Watt, .543 pence; double-acting engine, Boulton and Watt, .358 pence; double-acting engine, Boulton and Watt, .333 pence; Single-acting Cornish, Harvey and Co., .150. Whilst the water company are supposed to

give 7s. 6d. a ton for their coal, the average of the East London was 10s. 6d.

The Southwark and Vauxhall Company's total cost is at 10s. a ton for coal, .084 pence; or with five-sevenths for labor, repairs, wear and tear, etc., .144 pence.

The Grand Junction, with coal at 14s. 6d., is set down at for coal alone, .192, while labor, etc., added .276 pence.

The Liverpool Corporation Works present a comparison more nearly approaching the general pumping arrangements of a colliery's engines—both the ordinary crank engine and Cornish type are used; and the cost of pumping is given with great detail and accuracy. There are in Liverpool seven stations with nine engines. At the Bootle station there were three engines, each with beam and crank, and a single-acting bucket pump, and worked direct from the beam of each engine. Only two of these engines were worked together, and they delivered through an air-vessel. At the Bevington Bush station there was a bucket-lift, but it was altered to a plunger, and at once the total cost fell from .789 pence to .201 pence per million foot-pounds. Most of the calculations are based upon the returns for 1849; but, as indicative of the great saving to be effected by a large amount of duty performed, we may state that the engine at the Green-lane station of the Liverpool Company, which is Cornish, with a 56 in. cylinder, and a 9 ft. stroke, by Harvey and Co., which raised 992,000,000 gallons 100 ft. at a total cost of .222 in that year, was raising in 1865 as much as 2,736,000,000 gallons that height, at a total cost of .178 pence, the cost of the coal used being 6s. 10d. ton. And when the Southwark and Vauxhall raised 4,061,000,000 gallons, with coal at 10s. a ton, they did it at a total cost of .144 pence per million foot-pounds. The cost of coal alone at the Green-lane Liverpool engine was .075, and at the Southwark and Vauxhall, .084.

Hence it is concluded that the cost of coal for lifting 1,000 gallons 100 ft. high, or a million foot-pounds, need never exceed one-eighth of a penny where Cornish engines of the best make are employed; and that the total expense, exclusive of the interest of capital for doing this amount of work, might be within one farthing, instead of two or three farthings, which it often is.

"The Engineer" then discusses the South Staffordshire drainage, which is now a tax on the coal raised of 4½d per ton.

STRENGTH AND RESISTANCE OF MATERIALS.—In a paper "on the present state of knowledge of the strength and resistance of materials," read before the Institution of Civil Engineers, May 11, 1869, Mr. Jules Gaudard stated that the theory in the case was closely connected with that of molecular mechanics. But being a branch of that science altogether of practical application, it required only to borrow from scientific theories the principles on which to base rules of construction, simple enough to be of general application and yet sufficiently exact to be used with confidence. The formulæ of strength brought into view, on the one hand, the destructive action of external forces, and, on the other hand, the resisting power of the molecules of the material. External forces were of two kinds: one kind comprised elements directly given, such, for example, as weights; the other kind consisted of reactions—functions of given forces. In certain cases these reactions might easily be found by the science of statics alone, as, for example, in the case of a beam placed on two supports; in other cases they would depend on the changes of form of the solid. It was this, for example, which caused the difficulty of calculation in arches and in continuous beams of several spans. Or, lastly, it might happen that the body in question might not be in a state of equilibrium, but that its particles might oscillate under variable dynamic influences, or forces of inertia. This was the case of concussions, vibrations, etc. These various external forces being determined, it would easily be seen if they tended to cause certain parts of the solid to elongate, or to shorten, or to shear, or to turn round certain axes. These various effects, extension, compression, sliding, torsion, flexure, might further manifest themselves separately, or might combine with each other. Under the action of these forces, the body would necessarily be changed in form; for solids perfectly rigid were only pure abstractions. The study of these changes of form constituted the object of the theory of elasticity. The study of strength, or resistance, had to do with the power which the solid, according to its physical constitution, possessed to maintain, if not its form, at least the cohesion of its parts.

The author then proceeded to consider the forces of various kinds to which materials were subjected, such as extension, compression, sliding, flexure, torsion, and shearing; and in reference to all these, he gave the re-

sults and formulæ of the most modern investigations; expressing them at such length as to make them intelligible, but with sufficient conciseness to bring them within reasonable limits of space.

In conclusion, it was remarked that the theory of the strength and resistance of materials touched obscure problems relating to the physical constitution of bodies, and yet its practical character obliged it to be simple. Another motive, also, justified the departure from rigorous exactness, that was, the irregularity of the materials facts; if it was good, in effect, to associate mathematical science with physical phenomena, it was incontestable that these two elements, one always logical, the other frequently capricious, were often separated from each ether.

In spite, however, of these imperfections, the theory of the strength and resistance of materials in its present state constituted an elegant and useful doctrine, which ought to be better known by the majority of constructing engineers, so much did it tend to impress boldness and elegance on designs of all kinds. In any case, the theory, imperfect though it might be, had the great advantage of generalizing facts. Empiricism, if left to itself, would encumber the science of construction with a mass of rules, without reason or connection, well calculated to repel and mystify practical men.

IMPROVED ROAD ROLLER.—Gen. Green, of the Croton Aqueduct Department, New York, has introduced a roller consisting of a series of independent discs some 1½ in. thick (that is to say, 1½ in. wide on the tread), and a series of alternate discs of the same width, but of 3 in. less diameter, all mounted on a common shaft, so that the whole roller is grooved like the roll of an iron mill for producing 1½ in. square iron. As each disc moves independently on the shaft, facility of turning and avoidance of scraping while turning, are the result. But the most important result—and it is very important—is the increased hardness and *uniformity* of the road. A long solid roller can hardly be made heavy enough to crush down the protruberances of the surface; hence soft or uneven places are left between them. The grooved roller easily cuts into hard and projecting places, pressing the material laterally as well as vertically, so that the hollows are filled and the material is uniformly condensed.

THE COMPUTATION OF EARTHWORK.

From "Engineering."

We have, from time to time, illustrated and described several different arrangements for the mechanical computation of earthwork, by which the long and tiresome operation of calculating the cubic contents of the cuttings and the embankments of a railway can be substituted for a process of simple inspection, so that the quantities can be registered expeditiously, and with a minimum chance of error. A very ingenious instrument has recently been designed by Mr. W. H. Barlow for this purpose, and which will be found invaluable for making the computations necessary for framing parliamentary estimates, as well as for the more precise earthwork calculations during the progress of actual work. The instrument consists of a wooden circular tray, about 12 in. in diameter, in which are set cardboard discs revolving round a central pin fastened in the tray, and having engraved on their peripheries quantity scales of relative proportion. Upon the edge of the tray is screwed a brass stop, terminating in a flat finger, with a feather edge on one side and a zero inscribed upon its end.

The cardboard scales are of two classes, the height scales, referring to cuttings or embankments, ranging in height from 0 to 75 ft. These are engraved upon the larger disc, which entirely fills the tray, but can be turned round within it upon the center pin; the zero of this scale, in operating the instrument, is made coincident with the feather edge of the brass finger. The other is called the quantity scale, and is applicable for all widths and slopes of the height scales; it is graduated around the complete circle, and represents a total of 100,000 c. yards. This disc. is about 1 in. smaller in diameter than the outer one, which it overlies, and turns freely upon its center; its zero corresponds with that on the end of the brass finger. There is space sufficient upon that part of the under disc exposed beyond the edge of the upper, to allow of four or five height scales being drawn upon it. All these scales, by preference, refer to one formation width, with varying slopes; separate cards being prepared for different widths, and which can be easily placed on the tray by unscrewing the stop and lifting off the upper disc.

Both the height and the quantity scales are but the ordinary earthwork tables graphi-

cally stated. In constructing the former, the calculated cubic contents of a bank or cutting, of a certain formation, width, and side slope, forms the extent of the scales, each of the subdivisions of which represent the quantity contained for heights decreasing foot by foot to nothing, a constant length of 66 ft. being maintained, although, if desired, the scale may be divided into shorter lengths. These graduated quantities being thus drawn, are projected with ease upon the circular scales of the disc, and from which the standard quantity scale can be laid off.

In using this instrument, the height scale adapted to the intended slopes and formation width is selected, and its zero is accurately placed against the feather edge of the brass stop by means of a pointer; the disc is then fastened into its position by set screws. Then the zero of the quantity scale, free to revolve, is accurately adjusted to the 0 at the end of the brass stop. The longitudinal section having been divided into chain lengths, a steel pointer is placed on the rim of the quantity scale exactly opposite to that division on the height scale, which corresponds with the height or depth at the first chain. The disc is then brought round until the pointer touches the brass stop. Proceeding in this manner with each chain length in the bank or cutting, the total quantity may be read off on the quantity scale at the zero of the brass finger, provided the quantity does not exceed 100,000 c. yards, which is the total capacity of the complete graduated circle. If the whole contents, therefore, exceed 100,000 cubic yards, that amount must be added to every complete revolution of the quantity scale. It is obvious that the use of this instrument can be extended to computing the quantities to be added or deducted for any formation widths for which height scales are not provided; if the earthwork be first measured up with one base, and afterwards with a smaller one, the difference between the totals will give the cubic contents of a bank or cutting, with a formation width equal to the difference between the two bases used in the computation. This quantity divided by the width will give the cubic contents per foot of formation.

Although as designed no means are provided for computing the contents of banks or cuttings upon sidelong ground, it is obvious that this could be effected by a modification of the quantity scale, which could be adjusted to correspond with varying transverse slopes.

Altogether this instrument is the best adapted for its purpose that we have seen, and we are the more glad to bring it into prominent notice as Mr. Barlow proposes to devote any profits arising from its sale to the Benevolent Fund of the Institution of Civil Engineers.

GUIBAL'S VENTILATING FAN.

From a paper read before the Institution of Mechanical Engineers, by Mr. J. S. E. Swindell.

The fan employed at the Homer Hill Colliery, Cradley, has eight vanes, and revolves on a horizontal shaft within a cylindrical casing of brickwork, by which it is completely enclosed at the sides and circumference, with the exception of a circular aperture in the center of one side for the entrance of the air from the mine, and an outlet opening in the circumference for the discharge of the air into the outlet chimney. The area of the outlet opening is regulated by an adjustable sliding shutter, according to the extent of ventilation required; and the outlet chimney is built with a gradually increasing area up to the top, so as to reduce the velocity of the air at the point of discharge, and thereby prevent the loss of power that would occur in discharging it at the velocity of the fan. The fan is driven direct by a horizontal steam engine working a crank on the end of the fan shaft without the intervention of any gearing. The fan is 16½ ft. diameter and 4¾ ft. width, and its usual working speed is 26 revolutions per minute, discharging 13,500 cubic ft. of air per minute; and it can be got up in only about one minute's time to the higher speed of 96 revolutions per minute, discharging then 51,700 cubic ft. of air per minute. The current of air from the mine passes to the ventilator along an inclined drift leading off from the upcast shaft at a little depth below the top; and the top of the upcast shaft is closed by a movable cover, which is lifted by the ascending cage on arriving at the top, the weight of the cover being counterbalanced by weights. This is the first mechanical ventilator that has been applied in the working of the South Staffordshire Thick or Ten-Yard coal; and it has now been running about nine months, without a single stoppage for repairs of any description, and is doing excellent work, the total cost of the fan, with engines and connections, being

only about one-third of that of an ordinary ventilating furnace for producing the same amount of ventilation. A comparison of actual working between the furnace and the fan at a colliery in the north of England shows that with a consumption of only two-thirds as much coal, the fan supplies nearly double the amount of air obtained with the ventilating furnace. Several of these ventilators are now at work at collieries in different parts of the country, some of which are as large as 30 ft. diameter and 10 ft. width, capable of delivering 100,000 c. ft. of air per minute; and they are so free from liability to get out of order that no accidents of any consequence to the ventilation have occurred with any of them.

ILLUMINATING POWER OF COAL GAS.

From a paper on "Experiments on the Standards of Comparison Employed for testing the illuminating Power of Coal Gas," read by Mr. T. N. Kirkham, M. Inst. C. E. before the Institution of Civil Engineers.

It was observed that the standards of comparison at present in use were known to be wanting in that uniformity of result necessary for determining with accuracy the difference in the intensities of two lights. But as the amount of the variation had never been clearly defined, the author had instituted a series of experiments for the purpose of ascertaining the extent of these differences.

The instruments employed for testing the illuminating qualities of two flames were founded on the law of optics, that light diverging from a luminous centre diminished in intensity in the ratio of the square of the distance. This principle had been taken advantage of by Count Rumford in the instrument known as the "Jet Photometer," which was described; as was also another method, suggested by Professor Bunsen, which was dependent for its action upon the combination of reflected and transmitted light.

In France, the instrument employed was M. Foucault's modification of that proposed by Count Rumford, as arranged by MM. Dumas and Regnault; while the standard of comparison was the amount of light emitted from grammes of colza oil, specially prepared and verified, burning in a Carcel lamp, of certain fixed proportions, at the rate of 42 grammes (648 grains) per hour; and it was required that the light produced by from 25 litres to 27½ litres (.8625 to .9707 of a cubic foot) of gas, consumed in a Bengel burner of known dimensions, should be of equal power. The mode of conducting an experiment with this instrument was then detailed; and it was explained that during the progress of the experiment, the quantity of gas was regulated, so that the two lights should be maintained of equal intensity. In this way it was possible to compare the consumption of oil with that of the gas, and if the lamp had burned at the specified rate of 42 grammes (648 grains) per hour, the experiments should have been completed in 14 minutes 17 seconds.

In England, the instrument in use was constructed on the Bunsen principle, and the standard of comparison, as defined by Act of Parliament, was a sperm candle, burning at the rate of 120 grains per hour. The gas being consumed at the rate of 5 cubic feet per hour, through an Argand burner having 15 holes, and with a chimney 7 in. high, must be equal, in intensity of light, to 12 such candles.

The instrument by means of which the experiments were made by the author was also constructed on the Bunsen principle, combining all the most approved modifications. It consisted of four photometers, radiating from a common centre in the form of a cross, and each accurately scaled, adjusted, and fitted with every appliance to insure uniformity and precision.

The first series of experiments was undertaken for the purpose, if possible, of arriving at the amount of variation in the illuminating power of candles obtained from the principal manufacturers. Gas was adopted as a standard of comparison; and to insure uniformity in its illuminating power, a sufficient quantity for carrying out the experiments on each occasion was put into a gasholder in the labaratory, the temperature in the latter being always maintained at 62° Fahrenheit. In this series, each of the four photometers was supplied with candles of a particular make, to the use of which it was restricted throughout the day, every successive experiment being made with a separate specimen. All the candles were cut in half and burned from the centre. It was observed that, although the standard candle was fixed by Act of Parliament, as a sperm candle, of six to the pound, burning uniformly at the rate of 120 grains to the hour, yet no such candle was to be obtained; for from various quantities of sperm candles, six to the pound, procured

from several manufacturers, the average rate of consumption was 135 grains. This fact had been previously demonstrated by the extended series of experiments carried out by Professors Graham, Leeson, Brande, and Cooper, in 1852. The Parliamentary rate, being abnormal, was so rarely met with, that all operators had been compelled to make corrections for these variations, and had unanimously adopted the ordinary rule of simple proportion for the purpose. It was proposed, therefore, in the analysis of the diagrams exhibiting the results of the experiments, that the candles burning at the rate of 135 grains should be designated "normal standard candles," to distinguish them from the Parliamentary standard of 120 grains.

Commencing with experiments Nos. 56 and 58; in No. 56 with a consumption of 119 grains, the illuminating power of the standard gas was represented as 15.3 candles; whilst in No. 58, with a consumption of 121.2 grains, it was 14.5 candles. The difference between these two experiments, made with candles which happened to be nearly within the Parliamentary standard, was .8 of a candle. In experiment No. 51, burning the normal standard quantity of 135 grains, the same gas was represented as being 15.48 candles; and in No. 61, consuming 134.4 grains, or .6 of a grain less, it was 16.28 candles, the difference being in this case also .8 of a candle. In experiment No. 60, with a consumption of 134.7 grains, or only .3 of a grain more, the gas was shown to be 18.18 candles, a difference of 2.70 candles in experiment No. 51, with a consumption of 129 grains of sperm, the gas had illuminating power 12.6 candles. In experiment No. 52, with a consumption of 145.2 grains, the gas appeared to be 12.6 candles. Experiment No. 52, with a consumption of 157.2 grains, gave the gas as 12.54 candles. The last three experiments were examples of candles consuming different quantities of sperm, yet giving practically the same amount of light; the correction of which to the Parliamentary standard of 120 grains created error. Experiments Nos. 57 and 54, each with the same consumption of 130.2 grains, showed the difference in the illuminating power of the gas to be 2.42 candles; the former representing it as 13.02, and the latter as 1544 candles. These were examples of candles burning the same quantity of sperm, yet giving a different amount of light. The greatest difference in the illuminating power of the "standard gas as shown throughout the forty-four experiments made upon this day, was 4.60 candles; being between experiment No. 51, with a consumption of 129 grains, giving an illuminating power of 13.58 candles, and experiment No. 60, consuming 134.7 grains, representing the gas to be 18.18 candles.

An examination of the various diagrams would demonstrate, that the differences in the candles might be classed under five heads; viz., First. Differences in the illuminating power of Parliamentary standard candles, burning at the rate of 120 grains per hour. Secondly. Differences in the illuminating power of normal standard candles, burning at the rate of 135 grains per hour. Thirdly. Candles with different rates of consumption, giving the same amount of light. Fourthly. Candles with the same rates of consumption, giving a different amount of light. And fifthly. Greatest differences of illuminating power, in the whole number of experiments when corrected to the Parliamentary standard.

From the tabulated results of three other sets of experiments, it appeared that, in the first, when the consumption of sperm varied from 109.2 to 134.4 grains, the greatest difference in the illuminating power of the gas, corrected to the Parliamentary standard, was 4.59 candles; in the second, when the consumption ranged from 120.9 to 130.8 grains, the difference in the illuminating power was 3.06 candles; while in the third, with a consumption of from 120 to 142.5 grains, the difference was 4.21 candles.

The second, third, and fourth series of experiments were made with candles obtained from one manufacturer only. As an example of the results arrived at by the second series, it was stated that with a consumption of sperm varying from 129.6 to 130.2 grains, the greatest difference in the illuminating power was 2.26 candles.

Third series of experiments was made for the purpose of ascertaining whether the French standard of comparison, when used at a photometer on the Bunsen principle, was more reliable than the candle. It was thus found, that when the lamps were allowed to burn without any regular system of trimming, the variations were about as great as those of the candles; but when the lamp was trimmed before the commencement of each experiment, the variation was about the same as with the best candles. It was pro-

bable that the result would have been better, if the time allowed for taking the observations had been fifteen minutes instead of ten minutes; for the lamp when filled weighed 10 lb., and the balance employed would not turn to less than a grain. Subsequent experiments corroborated this supposition. Of this series the examples selected showed, in one case, that the greatest difference in the illuminating power of the gas was 1.69 candle, with a consumption of sperm ranging between 136.5 and 124.5 grains. In another case the greatest difference in illuminating power, corrected to the standard consumption of 108 grains of oil in ten minutes, shown in the whole number of experiments, was 2.3 candles, when the time required for the consumption of 108 grains of oil by the lamps was respectively 9 minutes 39 seconds and 10 minutes 3½ seconds.

For several years past the author had had in operation one of Mr. Lowe's jet photometers, for the purpose of indicating the illuminating power of the gas as it was being manufactured. As its apparent accuracy seemed to promise a more reliable means of determing the illuminating power of gas, it was decided to carry out a fourth series of experiments, with a view to discover the relation between the indications of this instrument and those of the French and English standards. At the "Cross" photometer, three consecutive experiments were made upon the quality of the gas, compared with four candles burning at the same time. The results of these twelve experiments were then averaged, and accepted as the illuminating power of the gas in each case. Another operator was at the same time engaged at the Dumas and Regnault photometer, and the average of these experiments was also taken as representing the illuminating power of the gas. Two of Mr. Lowe's jet photometers, fitted precisely alike, were in operation throughout these experiments; the orifice in each jet being of the same size, so that at any given pressure the height of the flame from each would be the same. The pressure at the point of ignition was regulated so as to give a flame exactly 7 in. in height and that pressure was duly recorded. The height of the flame at a pressure of .6 of an inch was also observed, as well as the time required for the issue of .1 of a cubic foot of gas under each of these pressures.

A diagram was prepared, showing the results of simultaneous experiments for ascertaining the illuminating power of different qualities, by two different systems, as at present existing, and by the proposed plan of testing by the jet. On this diagram a diagonal line had been drawn, which illustrated the theory of ascertaining the illuminating power of gas by means of the jet photometer, worked on the "Retrograde system," which might be thus stated: Maintaining a 7-in. flame from an orifice of certain fixed dimensions, the illuminating power of the gas was in direct proportion, inversely, as the pressure.

This diagonal line being considered as the "standard 7 in. flame," according to the theory just advanced, it was observed that the average results of twelve experiments very nearly coincided with the theory; and at pressures of .40, .51, .63, .64, and .68 of an inch this was especially the case. The highest and the lowest candle experiments were completely cut by the line, and the lamp experiments also tended generally to prove the theory.

Another diagram, representing the duration test corresponding with the retrograde scale, showed the time required for the issue of .1 of a cubic foot of gas, of a certain illuminating power, maintaining a 7 in. flame from the jet photometer. The use of the duration test was to check the working of the jet photometer, and to afford a means of discovering any irregularities that might occur in the apparatus. As an example of its use, it was seen by the retrograde scale that gas having an illuminating power of 14 candles gave a 7 in. flame at a pressure of .63 of an inch; and upon referring to the duration test it would be found that .1 of a cubic foot of gas of that illuminating power ought to maintain that flame for three minutes. Should there be any considerable deviation, it was an evidence of some derangement in the apparatus.

From these experiments the author believed it was evident that a more reliable method than that at present in use for determing the correct illuminating power of the gas supplied to the public was urgently needed; and he thought the following system would be found to give results approaching as nearly as practicable to a truthful estimate: Let the illuminating power of the gas be determined by the aid of the present recognized photometer, fitted with a Carcel lamp, burning oil of the same quality, and verified in the same manner as that adopted by the municipality of Paris as a standard; and

let a sufficient number of experiments be made so as to cover the errors that were known to exist, and the average of these be compared with the illuminating power, as shown by the jet photometer and the duration test, and then the "mean of comparison" might be taken as the illuminating power of the gas.

ENAMELING AND POLISHING.

From "The Art of House Decoration," by Mr. Sutherland.

In speaking of enamel, it must be understood as polished paint on the surface of woodwork, such as doors, architraves, window shutters, etc., etc. Enameling and polishing is an art which requires the exercise of the greatest care and patience in its execution. A little carelessness or inattention at the finish may undo the work of days. The work will not bear any hurry, either in the material or labor, but must go through its regular course, have its proper time to harden between each coat and process; and the rubbing down must be patiently and gently done—heavy pressure will only defeat the end in view. Great care should be taken in the selection of the pumice-stone, both lump and ground, as the slightest particle of grit or hard pressure will scratch, and thus cause hours of labor to be thrown away.

In describing the material used for the purpose, we shall only describe that which we consider best suited for getting up the white or light-tinted enamel. There are several kinds of filling up color used and sold by the colorman, but most of them are of a dark color, not suited for light work, as they require so many coats of paint afterwards, to get a pure body of color, that it defeats its own object. In practice, we find it best to fill up from the first with the same tint of color we intend to finish with, thus forming a solid body of pure color, which will bear much rubbing down without being shady. For all dark grounds, which have to be finished a dark color, the black or dark filling is the best.

The tools and material required are as follows, viz:

1. White lead ground in turpentine, and best white lead in oil.
2. A clear, quick, and hard-drying varnish, such as best copal, Manders Brothers' white coburg, and white enamel varnish, etc., etc.
3. Ground and lump pumice-stone, or putty powder.
4. Rotten stone, ground in water or oil.
5. Some white felt, from a quarter to half an inch in thickness, and of the best quality.
6. Several flat wooden blocks, of various sizes and forms, suitable for getting into corners and mouldings; these must be covered with the felt on the side you intend to use.
7. Two or three bosses made with cotton wool, and covered with silk.
8. Sponge, and wash or chamois leather.

In order to simplify the description, we will take a plain panel to operate upon. If it is new, give it two coats of oil color, mixed in the ordinary way; now mix the white lead, ground in turps, with only a sufficient quantity of varnish to bind it with, thinning to a proper consistency with turps. It is as well to add a little of the ordinary white lead, ground in oil, as it helps to prevent cracking. Give the panel four or five coats of this mixture, leaving a sufficient interval between each coat to allow it to dry well. Let it stand for a few days, until it is hard enough to rub down. When it is ready, you may rub it down, first with a soft piece of lump pumice-stone and water, to take off the rough parts. Now use the felt and ground pumice-stone, and cut it down, working the hand in a circular form or manner. You will require to exercise much care and patience to rub it down to a level surface, and without scratches. When you have got it down level, if it is scratched or not sufficiently filled up, give it one or two more coats, laying it on as smoothly as you can, and rub down as before. If done properly, it will now be perfectly smooth, level, and free from scratches; wash well down, and be careful to clean off all grit or loose pumice-stone. Now mix flake white from the tube with the before-named varnish, till it is of the consistency of cream. Give one coat of this; when dry, give another, adding more varnish to it. Now, let this dry hard, the time for which will of course depend upon the drying qualities of the varnish; some will polish in eight or nine days, but it is much the best to let it stand as long as you possibly can, as the harder it is the brighter and more enduring will be the polish. When it is sufficiently hard, use the felt and very finely ground pumice-stone and water; with this cut down until you get it perfectly smooth; now let it stand for a couple of days to harden the surface, then take rotten stone, either in oil or water, use

this with the felt for a little while, then put some upon the surface of the silk boss, and gently rub the panel with it, renewing the rotten stone as required. It is always better to rub in a circle than straight up and down, or across. Continue this until you have got it to a fine equal surface all over; it will begin to polish as you go on, but it will be a dull sort of polish. Clean off—if the rotten stone is in oil, clean off with dry flour; if in water, wash off with sponge and leather, taking care that you wash it perfectly clean, and do not scratch. You will now, after having washed your hands perfectly clean, use a clean damp chamois leather, holding it in the left hand, using the right to polish with, keeping it clean by frequently drawing it over the damp leather. Now use the ball of the right hand, press gently upon the panel, and draw your hand forward or towards you; if you do this properly, it will bring up a bright polish on the work, and every time you bring your hand forward a sharp shrill sound or whistle will be produced —if this is the case, you may be sure you are in the right path. Continue this until the whole surface is of one even bright polish. It will be some time, and will require much practice, before you will be able to do this in the best manner; but with perseverance and practice the difficulty will soon vanish. A soft smooth skin is best for polishing; if it is dry and hard it is apt to scratch. The latter part of these instructions referring to the polishing, will, of course, apply to polishing upon imitation woods and marbles, or on any polishing varnish, using the varnish pure, of course.

HEATING CARS BY STEAM.

Translated from "Polyt. Centralblatt."

Practical experiments on a large scale have been made in Germany on this subject, especially by the Brunswick Government R. R., the Prussian Eastern R. R., the Hanoverian Government R. R., and the Lower Silesian R. R.

On the Brunswick R. R. the steam was taken from the boiler of the locomotive, passing through a small cock of 1¼ in. interior diameter, into a large pipe of copper about 20 in. in diameter. Two such copper pipes were laid lengthwise below the floor of each passenger car, and connected by hose with the pipes of the adjacent cars. The pipes were covered by a grate along the walking floor. Under the seats they were covered by a wide box of sheet iron open in front so as to let the heat into the compartment and to protect the seats from the immediate radiation. These arrangements effected an increase of temperature in the cars of about 25° F., which is quite a favorable result.

On the Prussian Eastern R. R. the heating by steam of the passenger and baggage cars of the express trains was introduced in January, 1865. The steam is produced by a small tubular boiler standing in a compartment of the baggage car, and is carried along the train through a 1¼ in. pipe fixed to the lower part of the wagons. The maximum steam pressure is 30 lb. The pipes are joined by caoutchouc hose between the wagons. The heating of the compartments is effected by hollow cylinders connected below with the above described main pipe. The admission of the steam into the cylinders is regulated by cocks or valves from the outside of the wagons. It has not been found convenient to have this regulation done by the passengers from the inside of the compartments, and all the arrangements put in at first for this purpose had to be removed. The temperature in the wagons can easily be increased 50° F.

The steam pressure is very nearly the same over three wagon lengths, and consequently the heating power of the cylinders is about equal in the first three wagons. The above arrangements would therefore be sufficient for a larger number. No objections nor difficulties of any importance have been met with in using this system. The trains are running regularly over a distance of several hundred miles. The consumption of coal is about 1½ lb. per English mile, thus causing but a very small expense.

The Hanoverian Government R. R. runs daily two mail trains, with steam heating, between Cologne and Berlin. The steam is generated in a small tubular boiler put up in a compartment of the baggage car. The heating pipes are laid through the cars lengthwise, their axis being about at the level of the floor. The wagons of one train contain four parallel pipes of wrought iron, those of the other train contain but two pipes of sheet iron. Both kinds of pipes have a diameter of 2⅞ in. They are situated at a height of but one inch between the passenger seats, and located there immediately below the floor, so that a thin sheet of iron with which they are covered is even with the floor level. The emanation

of the heat takes place principally below the seats, where the pipes are uncovered. This emanation can be lessened and regulated by valves so arranged as to cover the pipes more or less. The valves can be worked from the outside of the cars by the employees, as well as from the inside by the passengers. On the first trial of these heating arrangements the temperature of the air was raised from 41° to about 60° F. The consumption of coal amounted to 25 lb. per hour, during which time 175 lb. of water were used. The whole arrangement has been found good and convenient. Further experience will show if it will prove sufficiently effective in severe frost.

The steam heating machinery actually in course of construction on the Lower Silesian railroad is similar in principle to that of the Hanoverian railroad. The details are not yet known. S.

IRON AND STEEL NOTES.

Silicon and Sulphur in Cast Iron.—The following practical remarks, on the making of pig iron, are culled by the "American Exchange and Review," chiefly from the new edition of Kerl's Metallurgy, by Dr. Crookes:

When casting pig iron in cast-iron moulds (chills), it will be found that the least silicon is contained in the lower part of the pig, on the other hand most of the combined carbon; whilst the upper part of the pig is richer in silicon and other substances which may separate. In such cases most of the manganese will also be found in the upper part. Upon casting pig iron in moist sand, the lower part of the pig is less modified. It is therefore advisable to cast good forge pigs in cast-iron moulds forming thin plates.

The following plans may be adopted for producing pig iron poor in silicon: Employing low temperatures and carbonizing the iron as perfectly as possible; or if a higher temperature is required, employing admixtures of lime to render basic the sufficiently aluminous mixtures from which silicon is reduced with more difficulty than from silicious mixtures poor in alumina; and, finally, adding manganiferous fluxes. The latter fluxes partly render the mixture easier to fuse, and the manganese combines with the silicon and separates on the surface of the liquid iron. According to Lohage, manganese, as well as aluminium, also facilitates the separation of silicon at the smelting of cast steel.

Good gray foundry pig iron may contain as much as two per cent of silicon; if containing a larger amount, it is harder and less strong, but it may be improved by remelting, when part of the silicon will be separated. Such iron, containing an excess of silicon, is fine grained, of light color, has but little lustre, and solidifies quickly.

Forge pig iron suffers more loss by scorification the more silicon it contains; it may, nevertheless, be more advantageous to produce pig iron rich in silicon and poor in sulphur, when treating impure ores at a high temperature, than by employing a low temperature to produce iron poorer in silicon and richer in sulphur, as silicon may be more perfectly separated than sulphur. The state of combination of the silicon essentially influences the behavior of the iron at its conversion into malleable iron.

Lohage suggests that gray forge iron should contain at least two per cent of silicon in order to form a slag which shall thus preserve the iron from further oxidation; and as the silicon first oxidizes, time is allowed for the separation of sulphur and phosphorus. Forge iron containing about 1.5 per cent of silicon is not usually desirable.

The higher sulphides lose in the upper parts of the furnace part of their sulphur, with iron, if iron is present in a reduced state, and if the temperature is sufficiently high. The sulphur in pig iron does not seem to be always combined with iron, but sometimes with silicon. Schafhäutl mentions an instance, that at the tapping of pig iron in the Tividale iron works, near Dudley, sulphide of silicon, of the composition Si^2S^3, analogous to the oxide of silicon, was separated in the form of a whitish-yellow, spongy, earthy substance. The sulphur is frequently not divided uniformly in the pig iron, and in the common pigs collects more in the upper part than in the lower part.

Additions of lime whilst applying higher temperatures, thus forming sulphide of calcium, which has the property of dissolving other metallic sulphides (sulphides of iron, manganese, etc.), and of sending them into the slag. This re-agent is more effective if the sulphur is contained less in the ore than in the gangue, fuel and fluxes, as, in the latter case, sulphide of iron is not at first formed, but sulphide of calcium, which directly enters the slag. Slags produced at Hattingen, from iron pyrites of the coal measures, contained from four to six and a half per cent of sulphide of calcium.

The Chemistry of the Blast Furnace.—The following are the principal points in the recent paper of Mr. I. Lowthian Bell, read before the Chemical Society:

Scheerer, Tunner and Ebelman, who have made experiments on the subject, have laid down with apparent precision the parts of the furnace, and the temperatures at which the different stages of the manufacture of iron—the reduction of the oxide and the union of the iron with carbon—take place. The former is commonly supposed to happen at a very considerable temperature, while the latter is commonly believed to take place in the hottest part of the furnace. Mr. Bell has arrived at conclusions altogether different. His results go to prove that the deoxidation of the ore takes place at a comparatively low temperature, and that the carburization is effected long before the metal is liquified and separated from the slag.

Mr. Bell dissents from Scheerer's representation of the various changes that go on in the blast-furnace, as taking place in zones; and he seems to attach much more significance to the term used by Scheerer than need be. The "Mining Journal" says: We are disposed to consider that the zones spoken of by Scheerer, where the reduction, carburation and fusion of the metal take place, are so far real that they are at least relatively different parts of the blast furnace, not, indeed, definable by absolute lines, but still in a certain degree distinct. That in certain furnaces the zone of reduction should

tend to assume the form of an acute cone, rather than a layer with horizontal boundaries, is quite conceivable; but whatever be the configuration of its vertical or horizontal areas, it is not the less distinct and different from the zones of fusion, carburation and calcination, where processes of a different nature are in progress.

The attainable economy of fuel in smelting iron is another point to which Mr. Bell directed attention. When it is considered that something like two and one-half tons of coal are consumed in producing one ton of pig iron, even when hot blast is used; and that to effect the chemical change of smelting, only eight hundred weight of coal are needed, still leaving one-half of the heating power of that coal unapplied, and available for further use, the great importance of devising means of economizing fuel in this operation will be obvious. More than four-fifths of the coal consumed in producing pig iron, is consumed in raising the temperature of the charge to effect fusion, and that is done under the most disadvantageous circumstances as regards production of heat.

The gases escaping from the throat of a blast furnace have not only a large amount of unused heat-generating power, but they have also a temperature and reducing power capable of preparing ore for the subsequent processes of the blast furnace. In the Cleveland district economy in this direction has been carried to a considerable extent, by increasing the height of the furnace, and thus taking off the gas at a lower temperature than is sometimes the case elsewhere. But it is from the higher heating of the blast that greater economy is now to be looked for. The idea that hot blast deteriorates the quality of iron is now pretty well exploded, and there is no reason that some advance should not be made in effecting economy of fuel by this means.

Accurate Rolling-Mill Machinery.—At length the managers of our finished ironworks are arriving at the just conclusion that most of the stoppages by the breakdown of machinery result from inaccurate adjustment and rude construction. Consequently gearing of absolute accuracy, and of greater strength with less material, is now in demand, and the works where these are produced are busy in that especial department. There can be no doubt whatever that a vast economy will result from the use of such castings, even as there is much saving yet to be effected in the engine department of our mills and forges. So soon as the iron trade generally shall see that it is not economy, but, on the contrary, extravagance, to cast their wheel gearing at home upon the old models, and shall go to our best machinists for what they require, and pay a very much larger sum for it, weight per weight, then we shall have less cumbersome apparatus, worked by engines which do not consume four times as much steam as with different gearing would be necessary. The losses which have resulted in the past year from stoppages by the breaking down of the unwieldly machinery too frequently to be observed thundering in our ironworks. are, to our knowledge in certain cases, somewhat startling. They are the more so because at neighboring works, where a heavier first cost was not shunned, and where, as a consequence, light, easy and almost silent working machinery is in operation, the stoppages have been of an insignificant character.

The foregoing is from the correspondence of "The Engineer." The same lesson has been learned by our progressive iron workers in America—and the result is the establishment of special manufactories of rolling mill machinery, such as that of Matthews & Moore, in Philadelphia, where trains of rolls are fitted up with the accuracy and solidity that characterize marine engines.

The Radcliffe Process.—An invention has recently been patented in England, by which it is claimed that masses of iron or steel may be produced of sufficient size to form girder, rail, shaft, armor plate, &c., which will be homogeneous throughout, in so far that they will be without any weld, in the ordinary sense of the term. Some years since, the welding of two or more puddled balls into one, under a steam hammer, was practised in Wales, and more recently in America, for instance at the Albany Iron Works; and by this means large masses were produced, but the process was not satisfactory, because the surfaces of the balls became oxidized, and good union could not always be secured between them in consequence. In the Radcliffe process, a number of puddled balls are worked together under a heavy steam hammer; but in the process here alluded to the puddled balls are welded together in a furnace, when the iron is surrounded by a neutral flame, and the oxidation of the iron is thus prevented. It is contended, also, that the cost of producing rails, armor plates, &c., by this process will be much less than by the ordinary methods. It is difficult to explain the arrangements connected with the furnace, without the aid of diagrams, but we may briefly state that a hydraulic anvil is made to work horizontally through an opening in one side of the furnace, and on the other a steam hammer is made to move in a similar manner. Thus mechanical appliances can be brought to bear upon the manipulation of a large or small quantity of iron. By an arrangement of rolls in front of the furnace, it is proposed to roll the iron into shape without reheating. The use of the hammer entering the furnace, to perform the welding in a neutral flame, was long since patented in America, by Alonzo Hitchcock, of New York.

Improvement in Iron Castings.—Messrs. Munro and Adamson, of Glasgow, have patented some improvment in the mode of manufacturing articles now made of malleable or wrought-iron, steel, or cast-iron from re-melted pigs, foundry scraps, or direct from the blast-furnace. Chills of the shape required for the articles to be produced are provided, and molten iron is run into them. As soon as solidified, and for the purpose of making the material very hard and dense, the casting may be taken from the chills and cooled in water or otherwise, or it may be allowed to remain in the chill for a longer period, or the chills may be surrounded with or cooled by water. In place of forming the chill castings of absolutely crude iron, the iron before being cast may be partly refined by blowing atmospheric air into its mass, or by placing compounds of oxygen into the vessel or furnace wherein it is refined. The chilled castings are afterwards annealed or tempered, thus producing a material possessing many of the properties of wrought, forged, or malleable iron, but avoiding the costly manufactureof iron now in use.—*Mining Journal.*

If we had not tried a part of this invention without success,we might believe it new and useful.—Ed. *V. N's Mag.*

CRYOLITE IN IRON FURNACES.—The "Colliery Guardian" contains the following paragraph:

"An invention patented by Messrs. James Bowron and George Lunge, of England, consists of mixing fluoride of calcium, the same being obtained artificially or in the form of a native fluor spar, or the mineral known as "cryolite," either in a state of fine division or otherwise, with the materials used in blast furnaces, for the purpose of removing, wholly, or in part, the phosphorus contained in the pig iron to be obtained therefrom. The invention further consists in using fluoride of calcium in puddling and other furnaces, to aid in the manufacture of wrought-iron and steel by the removal of the phosphorus contained therein. The phosphates resulting from such treatment may be utilized as manure."

We hear that the "Stevens Flux," notorious in this country for its brave promises and halting performances in the extraction of "more gold than could be found by ordinary assay," has already found a sphere of real usefulness in the metallurgy of iron—though we are not prepared to say that its application is novel or that its employment at the price charged for it will prove economical. As we have often said, whatever good qualities the Stevens Flux possesses are probably shared by native fluor spar; and now, for the consolation of Col. Stevens, we will reverse the case, and say that whatever advantages the above patent of Bowron and Lunge presents, are probably shared by his Flux. What's sauce for the goose is sauce for the gander.—*American Journal of Mining.*

COATING IRON WITH BRASS.—A new process has just been patented of coating iron with brass, copper, silver and other metals, which bids fair to work almost a revolution in some of the trades of Birmingham. One method heretofore employed is veneering—if that term be applicable to metal—but the expense and difficulty attending it have been an objection to it from the first. Electro-plating by various processes has been attended with much greater success, but even this coating is not so durable as could be desired. What has long been wanted is a method of coating iron with brass or silver, as readily as it is now coated with tin, and so as to render it equally durable. This has been at length successfully accomplished by a Wolverhampton patentee with remarkable success. The process adopted is that of immersion, but of course the details of the invention are for the present kept secret. I have seen, says the correspondent of "The Engineer," some sheets of iron which have been coated with copper on this principle, quite equal, for all practical purposes, to sheets ot copper. They will bear stamping into all imaginable shapes, and even burnishing, without removing the copper coat, the latter having to all appearance eaten its way into the inferior metal. Coated iron on this principle will supersede brass and copper to an enormous extent, for while it will be equally serviceable, it will be 40 per cent lower in price.

THE DUROMETER.—An instrument for testing the hardness of metals, by drilling, has been invented, says the "Builder," by M Behrens, an engineer of Tarbes. in France. It is said that it has been thoroughly tried, and that many French contracts for rails now contain a condition that they are to be tested by this apparatus. It consists of an upright cast iron standard bolted down upon a bedplate, and provided with a table for supporting the rail or other article to be tested. The spindle of the drilling tool is capable of being raised and lowered in its bearings by turning a handle for that purpose, and the drill is held down to its mark by a weight fitted to the upper end of the drilling spindle. Its rotary motion is derived, through a pair of mitre wheels, from a driving shaft carrying the usual fast and loose pulleys. This shaft has a worm upon it which moves a train of mechanism, in connection with a signal gong, for the purpose of indicating the number of revolutions made by the drill. The apparatus is exceedingly compact. Its use by French manufacturers has led to a gradual increase in the hardness of the rails they produce.

ESTIMATING THE IMPURITIES IN IRON.—Gintl gives a very easy method of determining the impurities in cast iron. It is applied by him to the estimation of the sulphur contained in the iron, but, as will be seen, it is available for the separation and determination of most of the usual impurities. The iron is reduced to as minute a state of division as possible, and is then treated with a strong solution of perchloride of iron, as nearly neutral as possible. The mixture is kept heated for ten or twelve hours, at the end of which time almost all the iron will be found to have dissolved, leaving, as a residue, the carbon, sulphur, phosphorus and silicium, together with the little iron left undissolved. This residue has only to be well washed, oxidized and dissolved, and the sulphur estimated as sulphate of baryta. The exact plan directed by the author is to introduce the residue and filter into a porcelain crucible, having, at the bottom, three parts of nitrate of potash and one part of hydrate of potash; heat to fusion, dissolve and precipitate with chloride of barium. The phosphorus and silica will be contained in the same solution, and can be determined separately. —*Mechanics' Magazine.*

A NEW FACT IN THE BEHAVIOUR OF IRON.—Mr. Gore has noticed a new fact in the behaviour of iron under the influence of heat and of strain. A strained iron wire was heated to redness by a current of voltaic electricity, and then, the current being discontinued, was allowed to cool. It was observed that there arrived a moment in the process of cooling at which the wire suddenly elongated, and then gradually shortened, until it became perfectly cold, remaining, however, permanently elongated. No other metal besides iron exhibited this peculiarity, which Mr Gore attributes to a momentary molecular change, and he points out that this change would probably happen in large masses of wrought-iron, and would come into operation in various cases where those matters are subjected to the conjoint influence of heat and strain, as in various engineering operations, the destructions of buildings by fire, and other cases. The phenomenon deserves a further investigation, since every fact relating to iron is of importance to us.—*Mechanic's Magazine.*

EFFECT OF PHOSPHORUS ON IRON AND STEEL.—With respect to the influence of phosphorus and slag in iron, Professor Styffe has a theory that the diffusion of slag through iron containing phosphorus, has a beneficial influence in counteracting the injurious effect of the phosphorus. The results of experiments as to the influence of this material

upon the tenacity of iron, agree pretty closely with those of Karsten and others. The author says: "The tensile strength of iron is not sensibly impaired by the presence even of 0.2 or 0.3 per cent of phosphorus, provided the metal has not been strongly heated after having undergone the operation of rolling or extension by other manipulation." He even maintains that the presence of even a considerable quantity of slag or cinder in iron impregnated with phosphorus is beneficial, by preventing the largely crystalline structure which would otherwise result from the presence of that element. With respect to the influence of phosphorus in steel, the author, on the contrary, confirms the opinion that it is injurious, rather than beneficial, and says that he knows no authenticated instance in which the proportion of phosphorus has been higher than 0.4 per cent in what has been considered as good steel.

TUNGSTEN STEEL.—It is many years since Mr. Mushet proposed to alloy iron with tungsten in the formation of steel. We reported a year or two ago that Mr. Leguen, in France, had made experiments with the same alloy, employing iron converted by Bessemer's process. Then he used a common gray pig, not fit for conversion, but produced, nevertheless, an alloy of very good quality. Lately, he has continued his experiments, now employing good white cast iron, and has produced a steel of excellent quality. A portion of the iron is first alloyed with one-tenth wolfram, in a cupola furnace, and is added to the rest in the converter. The conversion is carried further than usual, so that the carbon is reduced to one-half the ordinary proportion. The steel so produced is soft, but very tough, and tempers remarkably well. Mr. Leguen mentions that it will be found extremely useful for machines, some parts of which require to be tempered, while others are kept soft. The objection brought against this alloy is that it is expensive, but the amount of tungsten employed by Mr. Leguen is so small—only 0.55 per cent—that it can make but a very small addition to the cost of the steel.—*Mechanic's Magazine.*

TESTING BOILER-PLATES BY THE SAXBY METHOD.—During the past year the Saxby method of detecting flaws in iron, by the deflection of a magnetic needle, has been experimented with in England with especial reference to the detection of flaws in boiler-plates. In one of these trials a piece of partly used plate, that had successfully withstood all the Admiralty tests, was shown by the new method to possess a weak point; the existence of the defect and the efficacy of the method being subsequently proved by a re-examination of the plate by mechanical means. So successful have been the trials thus far made, that Mr. Saxby is led to claim for his method the attribute of infallibility.—*American Artizan.*

TO RENOVATE OLD FILES AND RASPS.—A file or rasp worn smooth is immersed for a time in a mixture of one part nitric acid, three parts oil of vitriol and seven parts water. The time it must be allowed to remain in this acid bath depends upon the quality of the metal. A very hard steel will require a longer immersion than a soft fine-grained metal. The tool is then well rinsed in water, and then (to ensure the perfect removal of the acid) in milk of lime. It is afterwards to be dried, and the lime is brushed away. When new files are made by this plan, they require a little additional treatment to protect them while in stock. After they have been carefully dried, and the lime has been brushed away, they are to be brushed over with a mixture of olive oil and turpentine, and, lastly, well rubbed with very fine charcoal powder. Any one would imagine that the acid, acting equally on all parts, would simply dissolve away some of the metal, and leave the file as smooth and useless as before. But such, we are assured, is not the case. Files may be renovated over and over again, and are always as good as new.—*Mechanic's Magazine.*

CASTING A 70-TON ANVIL BLOCK.—At the new Steelworks at Landon recently, a 70-ton block for a steam hammer, was successfully cast by Mr. Williams of St. Helen's Works Swansea. Two cupolas were specially erected at a suitable distance to enable the metal to run directly into the mould. Operations commenced at an early hour, and by a quarter to 10 a. m. the charges began to follow each other at regular intervals at three-quarters of an hour up to 9 p. m., at which time the block containing seventy tons of iron was finished. This is the largest casting ever made in Wales. The dimensions are 11 ft. 6 in. by 9 ft. 6 in. at base, and 7 ft. 6 in. high, and it will occupy from two to three weeks to cool sufficiently to allow it to be reversed, it having been cast base uppermost. Trunions joining part of the casting are so placed that it will simply be turned upon its own axes.

THE SIEMENS-MARTIN PROCESS IN FRANCE.—The Terrenoire Ironworks have now four Martin furnaces in operation. Ere now this process has been carried on, introducing scraps of Bessemer steel into cast iron. It is necessary, of course, that this cast iron be entirely free from phosphorus. Some trials have been made in the use of worn out rails instead of Bessemer steel, but that has been a complete failure. The rails were exceedingly brittle, and the railway companies have forbidden the mixture of old iron rails with the Bessemer steel used in the Martin process. This difficulty might be avoided with good iron obtained from a cast iron free from phosphorus, but the price of the steel would be greatly increased. This process will be very useful to the makers of Bessemer steel, enabling them to get rid of their scrap.—*Correspondence of The Engineer.*

RAILWAY NOTES.

FREIGHT CARS WITH CHANGEABLE GAUGE.—A new through freight line between Boston and Chicago, called the "National Despatch Line," are now running a through line of changeable gauge of freight cars, between those cities, passing over the Boston and Lowell and Nashua, Concord, Northern (N. H.), Vermont Central, Montreal and Vermont Junction, Grand Trunk and Michigan Central Railways, comprising the 4 ft. 8½ in., and 5 ft. 6 in. gauges. One hundred of those cars are now in use on the line; a part of which have been running since the 1st of January very successfully and satisfactorily, and it is intended immediately to increase the number of cars to five hundred, and afterwards to further increase the stock as the business requires.

ENGLISH LOCOMOTIVE EXPENSES.

COMPARATIVE STATEMENT OF HALF-YEARLY MILEAGE, LOCOMOTIVE EXPENDITURE, AND TRAFFIC RECEIPTS OF VARIOUS ENGLISH LINES.

Half-year ending January, 1869.

NOTE.—We gave last month a table showing the total expenses of the principal British lines. The following table, from "Engineering," gives the details of locomotive expenses on some of these lines.

	Great Western.			London and North-Western.			North-Eastern.			Midland.			Great Northern.		
	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total.
Train Mileage:									Estimated.			Estimated.			
Train, miles run	3,807,542	3,738,243	7,545,785	5,707,650	5,754,220	11,461,870	.....	.....	7,260,245	.....	.....	7,547,242	1,942,009	2,639,179	4,581,188
Engine, miles run	3,927,095	4,564,520	8,491,615												
	Cost.		Average cost per train mile.	Cost.		Average cost per train mile.	Cost.		Average cost per train mile.	Cost.		Average cost per train mile.	Cost.		Average cost per train mile.
Locomotive Expenses:	£ s. d.		d.	£ s. d.		d.	£ s. d.		d.	£ s. d.		d.	£ s. d.		d.
Salaries, office expenses and general superintendence	6,640 17 8		.21	12,140 11 1		.25	5,566 10 6		.18	5,249 18 2		.16	3,026 7 5		.15
Running Expenses:															
Wages connected with the working of engines	68,240 3 2		2.17	114,055 14 5		2.38	75,831 14 4		2.49	70,116 14 4		2.22	42,188 15 5		2.21
Coal and coke	47,165 5 0		1.50	80,610 0 3		1.68	80,244 5 9		2.65	53,639 18 9		1.70	39,678 12 10		2.08
Water	6,447 19 0		.20	3,894 14 5		.08	6,118 19 11		.22	5,794 0 8		.18	3,111 18 7		.16
Oil, tallow, and other stores	6,921 13 8		.22	12,686 13 5		.26	11,964 16 6		.36	13,111 15 4		.41	6,738 10 6		.35
	128,775 0 10		4.09	211,247 2 6		4.42	174,159 16 6		5.75	142,662 9 1		4.53	91,717 17 4		4.80
Repairs and Renewals of Engines, Tools, &c:															
Wages	61,356 11 11		1.95	82,143 8 7		1.72	57,595 1 6		1.90	40,361 8 2		1.28	37,291 7 4		1.95
Materials	53,740 16 3		1.70	75,473 5 3		1.58	48,671 13 6		1.60	64,196 17 0		2.04	32,622 3 7		1.70
	115,097 8 2		3.66	157,616 13 10		3.30	106,266 15 0		3.51	104,558 5 2		3.32	69,913 10 11		3.66
Repairs of workshops, sheds, and engine turntables	1,793 7 4		.05	4,056 11 7		.08	.....		.....	1,351 10 10		.04	†		
Gas	1,213 2 4		.04	.....		.....	4,801 19 10		.15	929 14 10		.03	2,114 14 5		.11
Total: Gross expenses	253,519 16 4		8.00	.....		.....	290,795 1 10		9.61	254,751 18 1		8.10	166,722 10 1		8.73
Less for power supplied	8,112 0 11		.....	.....		.....	9,338 7 9		.....	10,095 18 7		.....	5,354 19 10		
Total: Net expenses	245,407 15 5		7.98	385,060 19 0		8.06	281,456 14 1		9.61	244,665 19 6		8.10	161,417 10 3		9.18
Percentage on traffic receipts	12.12			11.22			14.12			14.55			14.19		
	Passengers.	Goods.	Total.	Passengers.	Goods	Total.	Passengers.	Goods.	Total.	Passengers.	Goods.	Total	Passengers.	Goods.	Total.
Traffic Receipts:															
Train miles	3,696,731	3,684,773	7,381,504	5,707,650	5,754,220	11,461,870	2,701,083	4,325,946	7,027,020	3,159,971	4,088,133	7,248,104	1,842,926	2,503,842	4,346,768
	Amount of receipts.		Pr. train mile.	Amount of receipts.		Per train mile.	Amount of receipts.		Pr. train mile.	Amount of receipts.		Pr. train mile	Amount of receipts.		Pr. train mile.
	£ s. d.		s. d.	£ s. d.		s. d.	£ s. d.		s. d.	£ s. d.		s. d.	£ s. d.		d.
Passengers	978,473 12 2		5 3.52	1,543,524 19 11		5 4.90	636,701 3 3		4 8.56	609,125 13 10		3 10.26	492,701 10 11		5 4.16
Goods	1,045,892 9 5		5 8.12	1,886,997 2 3		6 6.70	1,355,250 18 2		6 3.18	1,072,035 18 9		5 2.93	644,181 3 10		5 1.74
Total	2,024,366 1 7		5 5.81	3,430,522 2 2		5 11.83	1,991,952 1 5		5 8.03	1,681,161 12 7		4 7.66	1,136,882 14 9		5 2.77

FOUR COUPLED EXPRESS ENGINE—PARIS AND LYONS RAILWAY.—This type of engine may thus be generally described: Outside horizontal cylinder 17.33 in. in diameter by 25.6 in. stroke, four driving wheels 6 ft. 6.2 in. in diameter and 6 ft. 10 in. apart, and a pair of leading wheels 3 ft. 11.66 in. in diameter and 6 ft. 2.4 in. forward of front drivers. The driving wheels have only two springs, the axles being connected by compensating beams. The following particulars (and also engravings) appear in "The Engineer" of May 21, 1869:

	ft.	in.
Length fire grate	4	4
Width do	3	3¼
Surface of grate in square feet	15	0
Height inside copper fire-box near the tubes	5	3
Height near the door	4	10¼
Length at the top	4	2
Length at the bottom	4	4
Width	3	3½
Thickness of side plate	0	0¼
Thickness of door plate	0	3/8
Thickness of copper tube plate at the top	0	1
Thickness of copper tube plate at the bottom	0	0¼
Number tubes	164	
Outside diameter	0	2
Thickness	0	0 1/13
Length between plates	16	3¼
Length outside fire-box	4	11
Width at the top	4	2⅛
Width at the bottom	3	10⅛
Thickness	0	0¼
Outside diameter small plates of shell,	4	1⅛
Length of shell	16	0⅜
Height of the centre above the rails	6	4¼
Steam pressure	120 lb.	
Diameter of each of the two safety valves	0	4⅜
Heating surface fire-box, square feet	80	
do tubes, square feet	1260	
do total	1340	
Inside diameter chimney	1	4½
Height above the rail	14	4
Transverse distance frames	4	0⅜
Thickness do	0	1
Total length of the engine	29	7⅜
Diameter of leading wheels	3	11⅜
Diameter of driving and trailing wheels	6	6⅛
Distance from leading to driving wheels	6	2⅜
Distance from driving to trailing wheels	6	10
Total wheel base	13	0⅜
Transverse distance between wheels	4	5¼
Transverse distance between centers of journals	3	8½
Length of journals of leading wheels	0	9⅝
Diameter of do do do	0	6½
Length of journals of driving and trailing wheels	0	9⅝
Diameter of journals of driving and trailing wheels	0	7½
Number of plates in springs of driving wheels	16	
Thickness	0	0⅜
Width	0	3½
Length driving spring plates	3	9
Number of plates in springs of leading wheels	11	
Thickness	0	0¼
Width	0	3¼
Length	2	10
Camber	0	3⅛
Diameter of cylinders	1	5½
Stroke	2	1⅜
Length of connecting rod	5	11
Transverse distance between centers of cylinders	6	2⅛
Angle of advance of eccentrics	30 deg.	
Throw of eccentrics	0	2⅜
Stroke of slide valves in full gear	0	4⅜
Inside lap of slide valves	0	0 1/10
Outside lap of slide valves	0	1⅛
Length of steam ports	0	11⅛
Width of steam ports	0	1⅜
Width of exhaust ports	0	2⅜
Weight of empty engine	30 tons	8 cwt.
Length of connecting rod	8	4⅜
Diameter of connecting rod	0	4⅜
Length of coupling rod on driving wheels	0	3¼
Diameter of coupling rod on driving wheels	0	4⅛
Length of coupling rod on trailing wheels	0	3¼
Diameter of coupling rod on trailing wheels	0	3¼

Distribution of Weight in Working Order.

	tons.	cwt.
Leading wheels	9	9
Driving wheels	12	11
Trailing wheels	12	5
Total	34	

These engines run at an average speed of forty-five miles an hour, traversing inclines of 1 in 200 with trains weighing 115 tons, exclusive of the tender, which weighs twenty-three tons in working order. They are very steady, and the company have been so well satisfied with their working, that after a first supply of fifteen engines, fifteen more have been ordered.

THE RAILROADS OF THE UNITED STATES.—From a comprehensive abstract in the New York "Times," of Mr. Henry V. Poor's new work on Railroads, we compile the following statistics: There were in operation in all the States, on the 1st day of January, 1869, 42,255 miles of line, the cost of which, at $44,000 per mile, equaled $1,800,000,000. The total amount of net tonnage transported over them for the year equaled 75,000,000 tons, having a value of $10,472,250,000—a sum equaling six times their cost, and more than four times greater than the whole amount of the national debt!

The construction of these works upon a grand scale commenced with the discovery of gold in California, in 1848. The number of miles in operation in the country, on the 1st day of January of that year, was 5,599. The mileage annually constructed from the opening of the first section (23 miles) of the Baltimore and Ohio Railroad in 1830,

to 1847 inclusive, equaled 311 miles. The yearly average opened from 1848 to 1860, inclusive, equaled 1,925 miles—the aggregate opened in this period being 25,037 miles. During the war the number of miles built equaled 3,273, or 818 miles annually. Since 1864, 8,347 miles have been opened, or 2,086 miles annually. The number of miles opened the past year equaled 2,979 miles.

There are in progress fully 15,000 miles of line, of which at least 5,000 miles will be opened the present year.

The ratio of mileage of these works to our total population is as 1 of the former to 876 of the latter. The ration in the New England States is as 1 to 846 ; in the Middle, 1 to 1,037; in the Southern, 1 to 969; and in the Western, 1 to 731. The State of New Hampshire has 1 mile of railroad to 500 inhabitants; the State of Nebraska, 1 to 163; and the State of Florida, 1 to 343.

The State having the largest proportionate mileage is Massachusetts, which has 1 mile of road to 5.47 square miles of area. The State of Ohio has 1 mile of line to 11.76 square miles. A ratio similar to that for Massachusetts would give to the whole country 600,000 miles of line. One similar to that for Ohio, 300,000 miles. The total amount of net tonnage transported over all the railroads of the United States for the year 1851, did not exceed 5,500,000 tons. The rate of increase from that year to the close of 1867, in which year 75,000,000 of tons were transported, exceeded 1,300 per cent. The tonnage traffic of all the roads in the country in 1858 equaled 18,750,000 tons. The increase in the decade commencing with this year consequently equaled 300 per cent traffic.

The value of the tonnage for 1867 is estimated to equal that of the several classes of freight transported on the Erie canal for that year, (the value o. which is carefully ascertained,) or $139.63 per tonf The aggregate value of the tonnage of all the roads equaled, consequently, the enormous sum of $10,472,250,000. At a similar estimate the value of the tonnage transported in 1851 equaled $765,236,725; in 1858, $3,096,762,500. The total increase in value of the tonnage transported in 1867 over that transported in 1851 equaled $9,707,013,275, and $7,375,487,500 over that transported in 1858.

Our railroads transport, on an average, 2,000 tons to the mile. The tonnage of the railroads of Massachusetts, for 1867, equaled 5,394,137 tons, or 3,853 tons to the mile. That of the railroads of New York equaled 10,343,681 tons, or 3,501 tons to the mile ; that of the railroads of Pennsylvania equaled 35,383,370 tons, or 7,864 tons to the mile. The tonnage borne on the railroads of those States having a mileage of 8,750 miles equaled 51,121,140 tons, or 5,826 to the mile. The tonnage of most of the great roads far exceeded the estimate. The aggregate amount transported could not have been less than 100,000,000 tons.

Over ordinary highways wheat will bear transportation only 250 miles; Indian corn only 125 miles. Upon railroads these, the most valuable of our cereals, will bear transportation 3,200 and 1,600 miles, respectively. The area of a circle drawn upon a radius of 125 miles equals 49,077 square miles; that of a circle drawn upon a radius of 1,600 miles, 8,042,496 square miles.

The total earnings of all the roads in the United States in 1851 equaled $39,406,358. The receipts from freight and passengers were almost exactly balanced. The earnings from all sources in 1867 were $400,000,000, of which $280,000,000 were received from freight, and $120,000,000 from passengers. The rapid increase of earnings from freight is a most favorable feature. The earnings of the English railways in 1851 were $73,000,000, of which $35,000,000 were from freight, and $38,000,000 were from passengers. In 1867 their total earnings were $190,000,000, of which $105,000,000 were from freight, and $85,000,000 from passengers. The ratio, in this country, of earnings from freight to earnings from passengers is as 2.2 to 1; in England is a little over 1.1 to 1.

The earnings of American roads are more than twice greater than those of England. The railroad mileage of that country in 1867 was 14,247; in the United States, 39,276. The cost of the former, equaled very nearly $2,500,000,000, that of the railroads of the United States, for the same year, $1,700,000,000. The earnings of the English roads, upon their cost, equaled 7.86 per cent ; those of the United States very nearly 25 per cent. The English roads, however, have a great advantage over our own in operating expenses, their net earnings, as a rule, fully equaling one-half of the gross receipts. In this country the net cannot be estimated at over 30 per cent of the receipts. The following statement presents in detail the various items entering into the cost of operating the railways of the two countries—the railroads of the State of New York being taken as representing those of our own :

Items of cost per train, mileage of running trains upon the railroads of New York and Great Britain for 1867 :

	New York. Cents.	Gt. Britain. Cents.
Maintenance of way, including iron	49.50	12.70
Repairs of engines and materials	17.35	6 45
Repairs of cars	21.18	6.74
Wages of engineers and firemen	8.36	3.00
Fuel	21.60	3.42
Local taxes	5.50	2.20
All other charges	42.62	26.86
Total	166.00	61.37

The preceding statement shows the cost per mile of operating the railroads of the State of New York to be two and a half times greater than that of operating the railways of Great Britain. The earnings of our roads, however, per mile run are nearly twice greater—the average earnings of the former being $1 25 per mile ; of the latter about $2 30 per mile. The most startling difference in the items of cost is in the matter of fuel ; the cost of the same in this country being 21.60 per mile, in England 3.42 per mile.

In 1880 the population of the United States will equal 50,000,000. Its railroad mileage will equal 70,000 miles. At the estimate of only 2,000 tons to the mile their aggregate tonnage will equal 140,000,000 tons, having a value of more than $20,000,000,000, while our population is increasing at the rate of 1,200,000 annually.

THE NEW YORK CENTRAL Company recently paid a million of dollars for four acres of land for a terminus in New York.

LOCOMOTIVES OF THE PARIS, SCEAUX AND LIMOURS RAILWAY.—This railway has curves of 82 ft. radius. The engines have four driving wheels, but the wheels on the opposite sides are independent of each other, and are driven by two cylinders for the right and two for the left pair of wheels. The driving tyres are 12 in. wide, without flanges. The leading and trailing wheels are flanged, and are loose on the axle, (which is free to turn raidally to the curve), and they are fitted with "guiding bogies" which have wheels lying nearly horizontally and bearing against the inner edge of the rails. The following are particulars of the engines, from "Engineering," January 29, 1869, in which paper the machinery is illustrated.

	Engines with four cylinders, built in 1855, and subsequently altered.	Engines at Ivry in 1867.
Cylinders:	ft. in.	ft. in.
Diameter	11	16
Stroke	20	24
Distances between centers		9 4
Total width of engine		11
Wheels:		
Diameter of leading and trailing wheels	3 8	3 5
Diameter of coupled wheels	5	5
Length of wheel base	17	16 6
Boiler:		
Diameter of barrel		4 6
Number of tubes	134	201
Diameter		1⅞
Length	11	12 6
Height of top of firebox above grate		4 3
Length of grate		3 9
Width		4
Area	10 sq.	15 sq.
Heating surface; tubes (outside)	744 2,234 sq. ft.	
Heating surface; firebox.	56 80 sq. ft.	
Total	800 1,314	
Weight in working order:	tons.	tons.
On leading wheels	8	10.3
On front pair of coupled wheels	12	12.0
On hind pair of coupled wheels	12	12.0
On trailing wheels	8	8.7
Total weight	40	43.0
Weight available for adhesion	24	24
Capacity of water tanks	880 gallons	
Quantity of coal carried		2½ tons

One of the engines was subjected to some trials with a train of forty carriages. In passing round the terminal curve of 25 metres (82 ft.) radius, this train covered three-quarters of a circle; seven carriages projecting beyond the engine and half the train proceeding in the opposite direction to the latter. In another trial a train of thirty-seven carriages carrying 1,200 soldiers, run from Bourg-la-Reine to Orsay round the terminal circle at the latter place, ascended the incline of 1 in 180, and returned to the point of departure in 43 minutes.—The distance run was 28 kilometres, or about 17¼ miles, so that the average speed was about 24¼ miles per hour. The reverse curves at Palaiseau (328 ft. radius) was traversed at 25 miles per hour, and the terminal circle at Orsay at a speed of from 7 to 8 miles per hour. The total mileage run during the year is 236,000 kilometres, or 160,000 miles. The cost of maintenance of the carriage stock is 0.3 francs per kilometre, or 4.8d. per mile, and the cost for lubrication 0.18 francs per kilometre, or 2.88d. per mile. The cost of traction varies from 0.8 to 0.9 francs per kilometre, or from 12.8d. to 14.4d. per mile.

This system of locomotives and cars (similarly constructed) is that of M. Arnoux, and it has been in regular and successful operation for some fifteen years.

STEEL V. "BEST" IRON RAILS.—In the autumn of 1867, Captain Tyler and Mr. C. W. Eborall visited the Grand Trunk Railway of Canada and reported in great detail upon its financial, structural, and mechanical condition. Upon the question of rails, Captain Tyler observed in his report:

The difficulty of obtaining durable rails of iron has of late years been very generally felt, and has induced an outcry for steel rails in quarters where it would not otherwise have been heard. Much trouble has resulted, and much expense been incurred, for the want of rails of good quality in England, and still more in the United States, and in Canada. . . . In Canada, as elsewhere, after the failure, from lamination, of steel-headed rails, it has been considered that it would be better economy in the end to lay down steel rails than to continue to use iron with such lamentable results. . . . But I have, after careful inspection and inquiry, become convinced that iron rails of appropriate form, of suitable and reasonably good quality, and of sufficient hardness in the heads, may be made to last on most parts of the main line for fifteen years, and on the average of the Grand Trunk Railway for very much more. . . . The chance of procuring new rails of superior quality lies probably in insisting on a longer term of guarantee for the rails supplied, in employing the most reliable manufacturers and in paying a price commensurate with the value of the article. No manufacturer need have any fear of prolonging the guarantee to seven or even ten years if he only furnish a suitable rail.

The practical result of Captain Tyler's recommendations is not at all, however, what was wished, and it proves that the "outcry" for steel rails, to which he refers, was more than well founded. In the company's last report the directors remark:

The directors regret that the rails sent out from this country in 1867, purchased from the best makers, are not giving satisfaction. The directors took every precaution to secure the best rails which could be made, and exacted guarantees from the makers which they are putting in force. The small quantity of steel rails sent out in 1865, although placed on a part of the line where the traffic is very heavy, show no signs of giving way.

The engineers of the company, Messrs. E. P. Hannaford and J. F. Barnard, in their report to the directors, state that,

The rails latterly re-rolled in the United States and Toronto have proved superior to new rails imported from England. This is a very important fact, as we are of opinion new rails made from ores direct from the mine should be better in every respect than rails made from old material, which, from successive re-heating and the mixture of different qualities of iron, must of necessity prove

inferior to rails made from new iron properly manufactured. In former years imported English rails have stood the test of our climate with success, although of lighter section than those now laid; and we are unable to understand why English rails cannot now be made to stand, and must press upon you the urgent necessity of insisting upon the works employed to make rails for us in England turning them out better than those imported during the past two years. The complaint we now make about the quality of English imported rails is almost universal among all railway companies in the United States and Canada. The one-third of a mile of Bessemer steel rails laid in 1865, near Kingston, continue to show no failure; not one rail has been replaced, or likely to be for years, although the traffic at this place is more than ordinary. Some of the best iron rails laid at the same time and locality as the steel have had to be removed, and others, considerably worn, must come out this year. The general condition of the track and works, as compared with former years, is satisfactory, but we would again call your earnest attention to the question of the quality of imported rails, as, until we get English rails to stand, the annual cost of renewals of iron must of necessity continue heavy, and during the present year we must incur a large outlay, owing to the bad quality of most of the English rails, and their need of being replaced before they have lasted even the lowest average.—*Engineering.*

DUTIES ON PASSENGERS AND TONNAGE.—Mr. Ashbel Welch, General President of the Camden & Amboy & New Jersey Railroad Companies, states a very large case in a very few words, in Appendix G. of the late report of the said companies:

When these companies were incorporated, during the infancy and inexperience of railroad legislation, it was unfortunately provided that they should be taxed by transit duties on passengers and tonnage. This amounted to ten cents per passenger, and fifteen cents per ton between the Delaware and Raritan, and twenty-seven cents per ton, and not quite fifteen cents per passenger, between the Delaware and Jersey city. While only passengers and high-classed goods were carried by rail, this tax was not so severely felt; but when, contrary to the contemplation of the law, low-classed tonnage sought the rail route, its embarrassing and paralyzing effect was found to be greater than any one, not called upon to deal with the subject, can readily understand.

Where there is no tax on tonnage, it is the true interest of railroad companies to make a moderate profit per ton on a large tonnage. rather than a larger profit on small tonnage; for the increase of tonnage and consequent increase of intercourse increases their other business. But a tax on tonnage prohibits, or at least limits, this policy. For example: if the profit on one ton of railroad iron, between Trenton and Jersey city, is fifty cents, without transit duty, then, with the transit duty of twenty-seven cents, it becomes twenty-three cents net to the companies. But if, by reduction of rates, the quantity is increased tenfold, as in this case is probable (the cost in consequence being also reduced), and if the profit is then twenty-five cents per ton, without transit duty, the aggregate profit is $2.50, or five times as much as on the one ton; but, with the transit duty of twenty-seven cents per ton, there ensues a net loss of twenty cents on the ten tons.—So such a reduction, as is highly advantageous, without the transit duty, would be impossible with it. The transit duties on tonnage were, therefore, sometimes prohibitory—always restrictive in their operation—and cheap transportation was impossible. The odium of this fell mainly on the companies.—They were taxed excessively by an unexpected operation of the law, and punished by the public for being so taxed.

Efforts, heretofore made to cure the evil, have failed. Public men have feared to touch the subject, as the action required might endanger the revenues of the State. At last the companies appealed to the people, and found them in advance of their representatives. It was not supposed possible to do more at first than to modify the transit duties on the lower grades of property. But with the unexpected support, and even pressure, of the people, and under the enlightened advice of the chief magistrate of the State, the Legislature wisely abolished all transit duties, and substituted other taxation.

The new law, in effect, commutes the annual State taxation of the companies at that of 1868, which was not quite $300,000. The annual increase of transit duties paid the State for the last eight years has been between $15,000 and $16,000. The new connections of the companies' works, with the roads leading south and west, the pressure upon them of cheap property, at low freights, the diversion (consequent on the consolidation of the companies' interest) of traffic to the Jersey city route, where the taxation was highest, tend greatly to accelerate the rate of increase of transit duty that would have been paid, in addition to the acceleration due to the general increase and returning prosperity of the country. Large as the fixed amount to be paid is, it is much smaller than the transit duty would have become in a very short time.

But the greatest advantage of this change of taxation is, that it gives the companies the free use of their own works—removes the dam which has so much obstructed their traffic—allows them to increase their business without paying enormously for the privilege. The excessive disparity heretofore existing between the taxation of these companies and that of other railroad companies in the State, though not removed by this law, is prevented from increasing. The greatest burden was not the amount actually paid, but the amount that would have been paid if the roads had been worked to the best advantage.

BORSIG'S EXPRESS LOCOMOTIVES—These engines are used for what is termed "fast" passenger traffic on the Rhenish railway. They have four coupled wheels 5 ft. 6 in. in diameter. The leading wheels are 3 ft. 4 in. in diameter, and the total wheel base is 13 ft. 6 in., the distance between the centers of the coupled axles being 8 ft. 2 in. The trailing axle is placed below the firebox, the firegrate being inclined; and the driving and trailing springs are connected by compensating beams. The front ends of the two leading springs are also connected by a transverse compensating beam, which oscillates on a center below the front end of the boiler; and it follows from this arrangement that the engine is virtually carried on three points. All Borsig's engines are supported on the springs in this way, and the same or equivalent arrangements are adopted on almost all German locomotives.

The cylinders, which are 16 in. in diameter by 22

in. stroke, are outside; and so also is the valve gear, which is of the "straight link" kind. One peculiar feature in the boiler of the engine we are describing is the great height given to the firebox casing, a feature which has been extensively adopted by Borsig, both for the purpose of giving additional steam room, and adding weight to the engine at the hind end. In addition to the raised firebox casing the boiler is also provided with a dome 24½ in. in diameter and 3 ft. 5 in. high at the leading end. The front and back of the firebox casing above the firebox, and the smokebox tubeplate above the level of the tubes, are stayed by plates on edge secured to them by strong **T** and angle irons. The crown of the firebox is supported by being connected to transverse girders or stays, which extend across the firebox casing from side to side, and which thus serve as ties between these sides in addition to supporting the firebox crown.

The barrel contains 171 tubes, 1⅞ in. in diameter, and 11 ft. 1½ in. long, these tubes being of iron with copper ends. The heating surface of the firebox is 69 square feet, and that of the tubes (external) 930 square feet, making in all a heating surface of 999 square feet. The weight of the engine is 30 tons, empty, and 33 tons 14 cwt. when in working order, this latter weight being divided as follows:

	tons.	cwt.
On leading wheels	11	14
On driving wheels	11	6
On trailing wheels	11	14
Total	33	14

The engine is provided with a six-wheeled tender, weighing, empty, 11¼ tons. In the year 1867, Borsig supplied ten engines, of the class we have described, at the price of £2,650 per engine and tender, and last December he received a further order for twelve such locomotives at the price of £2,533 per engine and tender. This type of engine is illustrated in "Engineering," May 21, 1867.

MR. SCOTT RUSSELL AND RAILWAY FERRIES.—A little more knowledge of the facts, if not a reasonable amount of courtesy, would have saved some of our American newspapers, technical and otherwise, the discreditable mistake of abusing Mr. Scott Russell about what he has said and done regarding the introduction of railway ferries. The animus of the prime mover in this crusade against Mr. Russell may be observed in the wild way it goes about abusing that gentleman—for instance—by saying that the paddle engines of the Great Eastern were a failure, the fact being that they were a great success.

It seems to "rile" the American eagle beyond all endurance, that Mr. Russell designed and executed a ship to ferry railway trains across Lake Constance, and then described it in a paper before the Institution of Naval Architects, and urged a similar means of transit between England and France. And why? Because the same thing was done in America before! To be sure Mr. Russell said in his paper, "I must say that it is not me the English people have to thank for having made this experiment for them." He described a work of his own, and as his own, when a similar work had been done in America *before*. That is his offense. Suppose he had built a North river steamer or a twin screw, and had then urged their farther adoption and magnified the details of his own work without claiming credit for the general idea. Should we have gone mad over that? The railway ferry is as notoriously of American origin as the North river steamer or the twin screw. Or must Mr. Scott Russell begin by praising American genius every time he speaks of his constructions of the American type?

Mr. Russell *has*, on several occasions, described the Havre de Grace railway ferry as a brilliant feature of American practice, and he has always been the admirer and advocate of the many good features in American marine and mechanical construction. A native yankee, "with the stars and stripes grown onto his back," could not have rendered more frequent and hearty, and possibly not more graceful, tribute to the American practice than Mr. Scott Russell has rendered, in his many speeches and writings, for the last fifteen years. In fact, the greater part of the literature concerning the American steamboat practice has been made by Mr. Scott Russell and his son. For an American engineer to abuse Mr. Scott Russell is simply disgraceful.

APPARATUS FOR TESTING RAILS.—Mr. Charles T. Liernur, formerly of Mobile, and now resident abroad, patented some nine years since, an apparatus of which the following is the specification:

"The object of my invention is to construct an apparatus in which the rail is subjected to a course of trials similar in its results to actual usage when laid upon the road. For this purpose I lay a circular track composed of 3, 4, or more rails (or pieces of rails), making a circle of from 20 to 30 or more feet in diameter. On this track I place a car supported by four, six, eight, or more wheels, all the axles of which point towards the center of the circular track. The wheels to be of the size, pattern and make as actually are to be used upon the road for which the rails are to be tested, and the car to be loaded with the weight per wheel equal to the greatest load they will have to sustain when in use upon the road. The vertical shaft to be well braced, and to be strongly attached to the car, so that when a rotary motion is given to the former, this motion will be participated in by the latter, a beveled cog-wheel being placed at the top or bottom of the shaft for the purpose of revolving it by means of a stationary steam engine placed near by.

"What is claimed as the invention is a railway car revolving by means of a center-shaft, and supported by four, eight, or more wheels, the axles of which point towards said shaft, and running said car upon a circular track of railway rails for the purpose of submitting both rails and wheels to a test of usage."

This plan has recently been proposed in England by other parties, and it is to be hoped that the experiment will be carried out.

ROLLING STOCK OF THE CENTRAL PACIFIC.—This Company has now running 150 locomotives. Besides these there are seven partially set up in San Francisco. There are several more contracted for, yet to arrive. The engines, in running order, are from eleven different makers, the largest number from one firm being 47 from McKay & Aldus, 28 from the Danforth Locomotive Company, 24 from the Schenectady, 10 from the Rhode Island, etc., only one being from Booth & Co., San Francisco. Two have drivers 3 ft. 9 in. diameter;

about twenty have six drivers 4 ft. diameter; twenty-five have six drivers 4 ft. 6 in. diameter; forty have four drivers ranging from 5 ft. 6 in. to 5 ft. diameter; sixty have four 5 feet drivers each; and two have four 5 ft. 6 in. drivers. Excepting two small locomotives, with two drivers each and 11 in. cylinders, 15-in. stroke, the locomotives run 16, 17 and 18-in. cylinders and 22 and 24-in. stroke. The engines under contract have six drivers, 5 feet diameter, 18-inch cylinder, and 24-in. stroke.

The Company owns 1,400 platform cars, nearly all of which have been made at Sacramento. The total number of box cars on the road is 360, with an increase at the rate of 30 a week. Of composite baggage, mail and express cars, there are 17 in work, and others constructing. Of hand cars and track cars and section cars, there are 123, and more making. The passenger cars are not very numerous; but besides ten in use, four are making in the shops and there are ten contracted for in the East. The Company also own a handsome family carriage. The sleeping cars will come from the east, and will be kept on those sections of road where night traveling is done.—*American Railway Times.*

TIE-SPOTTING MACHINE.—This device, built by Mr. Jauriet, of the Chicago Burlington and Quincy shops at Aurora, is thus described by the "Chicago Railway Review:" Our readers are aware that rails are generally laid level upon the ties, with the result of bringing the whole weight of the car upon the inside of the rail and the inside of the inclined rolling surface of the wheel. Mr. Jauriet conceived the idea of laying the rail so as to incline inwards on the same level as the surface of the wheel. The old hand process of doing this, with adze, is slow, unequal, and costs more than it comes to. The tie-spotting machine—attached to a car and transported from place to place on the line—may be generally described as consisting of two vertical shafts, with knives attached, to which the ties are brought by means of a chain-feed. The knives are adjustable, so as to "spot" at an angle, or in the ordinary manner. The machine is operated by the engine attached; and requires, besides the engineer, six men to operate it, who do the work of from fifteen to twenty. A recent experiment resulted in the spotting of seventy-six ties in fifteen minutes.

CHICAGO, BURLINGTON AND QUINCY SHOPS AT AURORA.—We condense the following from the "Chicago Railway Review:" The present old works at Aurora are to be enlarged as follows: Car shop, 400 by 100 ft., two stories; setting up shop, 200 by 90 ft.; car machine shop, 100 by 90 ft.; car smith shop (nearly done), 200 by 90 ft.; paint shop, 200 by 90 ft.; drying kilns, lumber sheds, a tin and brass shop and a fire proof engine and boiler house. The old engine house (40 stalls) will remain, and another will be added. The present machine shop is 185 by 50 ft., stocked with Bement's and with Sellers' tools, among which are 26 lathes, 8 planers, and 7 drilling and boring machines. The present smith shop is 80 by 50 ft., and has a 4,000 lb. Bement-Davy hammer. The boiler shop is 60 by 50 ft. There are also a brass foundry, an oil house, and a rail repairing shop. The locomotive superintendent is Mr. C. F. Jauriet, and the superintendent of the car department Mr. W. W. Wilcox.

CHICAGO AND ALTON SHOPS AT BLOOMINGTON.—The original shops at this place were burned in 1867. Temporary works were improvised within the old walls. The new works are more than half completed, and will have cost about five hundred thousand dollars. They are built of rough dressed stone, and have slate roofs on iron trusses. Gas lighting and steam heating are extended to every part.

The two engine houses (one completed) are 230 ft. in diameter, for 28 locomotives each. The machine shop will be 260 by 100 ft. with a wing 80 by 45 ft., and engine and boiler house attached. There is to be a transfer table outside of this building.—The smith shop is to be 200 by 100 ft.; the boiler shop 180 by 60 ft.; coal shed 125 by 40 ft.; iron house 80 by 50 ft.; foundry 210 by 60 ft., and cleaning room attached, 50 by 45 ft.

The car shop is 263 by 80 ft.; the car machine shop 200 by 75 ft. (2 stories), with outside transfer table and attached engine house; the paint shop 172 by 75 ft. A two story office and store building, 120 by 60 ft., is centrally situated.

The superintendent of machinery is Mr. J. A. Jackman; the superintendent of the car shops is Mr. Rufus Reniff.

COMMUNICATION BETWEEN PASSENGER AND GUARD TO BE ENFORCED IN ENGLAND.—The Act for the Regulation of Railways, passed last session, provided that "after the 1st of April, 1869, every company shall provide and maintain in working order, in every train worked by it which carries passengers and travels more than twenty miles without stopping, such efficient means of communication between the passengers and the servants of the company in charge of the train, as the Board of Trade may approve. If any company make default in complying with this section, it shall be liable to a penalty not exceeding £10 for each case of default. Any passenger who makes use of the said means of communication without reasonable and sufficient cause, shall be liable to a penalty not exceeding £5." The Board of Trade have extended the time in order to afford further opportunity for further testing the merits of the numerous plans submitted to the companies.

STEEL RAILS.—Steel rails, it is reported, are to be laid on the entire length of the railroad from Paris to Marseilles. The change from iron to steel will require 137,000 tons of steel. From experiment made by the company, it has been calculated that in the vicinity of the stations iron rails will not last over eight or ten years. The steel rails, it is believed, will last thirty or forty years. The bridges are to be constructed of steel as soon as iron ores suited to the manufacture can be obtained in sufficient quantity.

The Erie Railway Company have completed 17,000 tons of steel rail on their road—not a broken rail since. They have purchased the New Jersey Iron Works and those at Elmira, and are now turning out about 400 tons of steel rail every month. Within a year the whole line will be relaid.—*American Journal of Mining.*

LOCOMOTIVE BOILER EXPLOSIONS.—No fewer than fourteen locomotives have exploded within the seven months ending June 1st, in the United States, killing twenty-nine persons outright and severely wounding a much greater number.

THE BROAD GAUGE, as regards the midland districts of England, is now a thing of the past, the Great Western Railway Company having ceased to run any broad gauge passenger trains between London and Birmingham, Wolverhampton and Liverpool. Already, too, on the branch between Reading and Basingstoke, the third rail has been removed, thus converting that line from a mixed gauge into an entirely narrow gauge line, and connecting the Great Western system with the London and South-Western Railway and the south of England. In addition to this, the whole of the broad gauge lines north of Oxford will immediately be taken up, removing in the midland counties the last trace of the system of one of the two great rival engineers, whose plans were so long hotly contested, and celebrated as "the battle of the gauges."

ANOTHER BRIDGE ACROSS THE MERSEY.—Messrs. William Low and George Thomas, civil engineers, have submitted to the Mersey Dock and Harbour Board a letter and plans, illustrating their scheme of crossing the Mersey by means of a railway suspension bridge between Liverpool and Birkenhead. It will consist of three spans, the center one 1,800 ft. in length, and the others 960 ft. each, and will be 140 ft. above high water mark. The bridge would unite the various railway lines in Lancashire and Cheshire. It will be under two miles long, and the total cost is estimated at £1,750,000. This would be the sort of thing to try our engineering mettle before we venture to bridge the Irish and British channels.

NEW INDIAN RAILWAY.—Operations in connection with the laying out of a new and important line of railway communication have just been commenced by a staff of British civil engineers. The line is designed to connect Carwar, on the Malabar coast and the cotton districts of Hooblee and Dhawar, with the probability of its being carried through into the Madras Presidency. The line is to be designated "The Southern Mahratta and Mysore Railway." There will be formidable difficulties to contend with in "carrying the line up the densely-jungled ghaut," with an elevation of some 1,500 ft. The undertaking is to be carried out under the direct orders of the government.

THE ST. GOTHARD RAILWAY SCHEME.—It is rumored that, in addition to a subvention of 50,000,000f. to this scheme, Prussia is now ready to renounce her real or imaginary rights over the Swiss territory. The project has been well received in Switzerland, the Northern and North-Eastern Railways each contributing 9,000,000f., whilst the various German cantons will, it is expected, vote considerable sums in addition to the Federal subsidy.

THE CHANNEL BRIDGE.—M. Boutet's system of excessively long spans (3,282 yards) is being tested by *models* of one hundredth size, and upon the success of one, the "Journal Officiel de l'Empire Francais" says: "The project of a bridge over the straits makes each day further progress." • • • "The problem is resolved that bridges and viaducts of *every size* can be constructed in a single arch without piers from bank to bank!"

THE CREUSOT works have secured a fresh order for locomotives (fifty-five altogether) on Russian account.

LEGISLATION TO AID RAILWAYS.—During the five weeks' session of Congress, thirty-one bills were introduced in the Senate alone contemplating grants of public lands, bonds, or credit, or all three, to railway projects. The land grants proposed vary from one to eighty thousand sections in each case, and amount in the aggregate to about two hundred million acres.

RAILROADS VS. STEAMBOATS.—Drawing-room cars and steel rails are beginning to furnish those solid comforts which pleasure travelers have heretofore considered peculiar to steamboats. The roominess, upholstery and decoration of steamboats are all that could be desired, but there should be better ventilaton of dining-saloons, less early blowing off of steam, and more polite attendance.

FAST RUNNING.—Trains on the fast railway line between Liverpool and London can now be driven at the rate of fifty miles an hour, and the whole distance (200 miles) accomplished in four hours. There is no stopping for water, this being scooped up from troughs between the tracks while the train is running at full speed.

CONNECTICUT RIVER BRIDGE AT MIDDLETOWN.—The Keystone Bridge Company, of Pittsburgh, have contracted to build the new wrought iron bridge on the Boston, Hartford & Erie road at Middletown, Ct. It will be of 1,200 feet span, and will cost $176,000.

NEW BOOKS.

GEOLOGY OF NEW JERSEY. By authority of the Legislature. GEO. H. COOK, Geologist. 8vo. 899 pp., with portfolio of eight large maps. Published by the Board of Managers, 1868. New York: D. Van Nostrand.

This substantial volume gives the final report of the geological survey of New Jersey. The first survey of this State was made by Prof. Henry D. Rogers, the report of which was published in 1840. A subsequent survey was conducted by Dr. William Kitchell, geologist, and Prof. George H. Cook, assistant, during the years 1854, 1855 and 1856. But before the survey was completed, the failure of legislative appropriation compelled its close. The present survey was authorized in 1864, under Dr. Cook as geologist, and the result of the four years' labor and investigation of him and his assistant is given in this volume.

It consists of two distinct portions; the first, comprising about one-third of the volume, is a strictly scientific exposition of the geological formations found in the State. The work, in this department, has been mainly expended in extending the geological systems of New York and Pennsylvania into the corresponding formations of New Jersey. This has not been entirely without difficulties, because not a few unsolved mysteries had been bequeathed by the geologists of the neighboring States. The task, however, has been thoroughly done, and much light has been thrown on the intricate questions of fossil and lithological geology. In the appendix to the volume will be found some valuable catalogues bearing on these scientific inquiries.

The second portion of this work will be found to the general reader more interesting, and to those interested in developing the resources of the State, of the greatest value. It treats of the economical

products of the State with a fullness and thoroughness which will be found equaled in no similar work. In this respect Dr. Cook and the managers of this survey deserve the thanks of the people of New Jersey and of her neighbors. To the agricultural public this complete exposition of the extent, the value and the characteristics of those marvelous beds of marl, will be most acceptable. Literally this fertilizer has for New Jersey turned the wilderness into a fruitful field. Many, for the first time, will find in this work the first systematic and satisfactory explanation of its value as a fertilizer. To those interested in mining, the chapters on the iron regions will be found especially acceptable. A special map is devoted to this region, and the location and direction of all the known iron beds are here laid out. It will surprise not a few to learn, from this work, that New Jersey, although standing twentieth in the scale of population among the States of the Union, furnishes one-eighth of all the iron, and in manufacturing iron stands fifth.

In other economic products New Jersey is unusually rich. One-half of all the zinc product of the United States is derived from her mines. Her clay beds furnish a vast variety of clay, from that suited for manufacturing common brick to that which will produce the finest porcelain. She has peat beds which will furnish a bountiful supply of fuel when the coal beds of Pennsylvania are exhausted. She has immense beds of sand, which is in demand for the manufacture of glass, fire-brick, and concrete stone. Her manufacturing interests are scarcely less important than her agricultural. Newark has grown to be a city of 120,000 inhabitants, and is the third city of the Union in the value of its manufactured products.

Situated as New Jersey is, between the two greatest markets of the United States, she can never fail to be one of the most important sections of the country. Cheapness of transportation, the certainty of a market even for the most perishable products, the fertility of her soil, the industry, thrift and intelligence of her inhabitants, ensure for New Jersey a rapid development of her resources, and an unexampled career of prosperity. To this rapid development this valuable report of Dr. Cook cannot fail largely to contribute. The Legislature has wisely decided to continue the survey under the same admirable management for an additional period.

MODERN PRACTICE OF THE ELECTRIC TELEGRAPH.—A Handbook for Electricians and Operators. By FRANK L. POPE. New York: Russell Brothers, Publishers, 28, 30, and 32 Center street.

During the quarter of a century which has elapsed since the introduction of the electric telegraph in the United States, those engaged in its service have been almost entirely dependent upon verbal instruction, and long practical experience, for a thorough technical knowledge of their profession. The works heretofore published on the subject have been of a popular rather than of a scientific or practical character, or else of so elementary a nature as to be of little service except to very inexperienced students.

The work before us, though very concise, is a treatise suitable for the practical electrician and telegraph operator; but it will also be found serviceable to the student as well as to the more advanced electrician. Its author, who, though a young man, is a telegrapher of many years' experience, and has a thorough scientific knowledge of all that relates to the telegraph, goes very fully into the various branches of the subject—batteries, magnets, circuits, and insulation. The book contains a very complete description of the Morse or American telegraph system, explains the testing of telegraph lines, gives notes on telegraphic construction, and hints to learners, and concludes with very copious notes on various minor details.—*American Artizan.*

LEHRBUCH DER GESAMMTEN TUNNEL-BAUKUNST. VON FRANZ RZIHA. Ernst and Korn, Berlin, 1868.

The fourth part of the second volume of this magnificent work of Rziha's, which we have noticed at length in past pages of the "Practical Mechanics' Journal," has appeared; and all we need say of it is that it fully sustains the reputation of the preceding parts.

In the present part the Belgian, German and Austrian systems (for they all differ a good deal) of tunneling are fully described and critically compared. This is followed by an elaborate comparative critique and estimate of costs, of timber-frame tunneling, with a chapter or two on the methods of lining with masonry under diverse conditions; and these lead on to the commencing chapters, in which the author is about to describe his own peculiar system and construction of cast and wrought-iron moveable framing for tunneling without timber, of which we before now gave a tolerably complete sketch to our readers.—*Practical Mechanics' Journal.*

LEITFADEN ZUR BERGBAUKUNDE &c. VON BERGRATH H. LOPTNER. Bearb. u. herausg. von A. Serlo: Erste Liefrg.

We may fitly place this work after that of Rziha, for it treats of a very analogous subject. Tunneling and shaft-sinking for railways have much in common, and have in fact borrowed much in practice from level and adit driving and shaft-sinking for coal and other mining. These last are the operations here treated of, and treated of with the ability we are prepared to expect from the reputation of Bergrath Lottner, well known in Germany for his grand maps and sections of the coal formations of Westphalia, &c., and as a Professor of Mining in the Royal Mining Academy of Berlin. The present part treats mainly of sinking and driving through various "ground," and includes all the new machinery for boring and holing each, and the new and old explosive agents. The work will be completed in three large parts (or volumes, we may almost call them,) with many illustrations by excellent woodcuts; and the successive parts will embrace every head of subject belonging to the miner's art, so far as the entering the ground, securing it, and keeping the shafts, &c., level water and foul air free, are concerned. It excludes, as belonging to metallurgy proper, the treatment of the material, of whatever sort, extracted by means of the excavations made.—*Practical Mechanics' Journal.*

THE MANUFACTURER AND BUILDER. May, 1869: New York. Western & Co., 37 Park row.

This monthly journal contains 78 columns of interesting matter and numerous engravings for 15

cents—a marvelously cheap technical publication. The articles in the May issue for instance, are 60 in number, 10 of which are illustrated; the following are of special interest: The Telephone, Boiler Explosions, Beton building, Hydraulic Mortar, Hydrogenium, Magenta (analine color), Church Architecture, Interior Decoration. A journal giving so much information at such a price, deserves success.

WOODWARD'S NATIONAL ARCHITECT; containing 1,000 original Designs. Plans and Details to Working Scale, for the Practical Construction of Dwelling Houses for the Country, Suburb and Village. With full and complete sets of specifications and an estimate of the cost of each design. By GEORGE E. WOODWARD, Architect, Author of "Woodward's Country Homes," "Woodward's Cottages and Farm-houses," etc., etc., and EDWARD G. THOMPSON, Architect. New York: George E. Woodward, 191 Broadway.

High rents and close quarters are driving the inhabitants of cities like New York into the country with unprecedented rapidity, and, thanks to our railroads, it is now nearly as easy to live twenty miles out of town as to live in the upper part of the city. The loss of time is about as great in the one case as in the other, while the advantages of a real country residence are so great, especially to children, that no sensible man will stay in the city if he can possibly make his escape. To those who contemplate taking a part in this exodus the work we have just recited will prove invaluable. It is filled with chaste designs for conveniently arranged dwellings.

The plan of the work embraces designs for houses of moderate valuations, estimated at New York prices as a basis, with such detail prices as will enable one to ascertain the cost, in his own locality, by comparison with the different rates of prices that always exist in different sections of the country.—The forms of specifications given are such that they may be adapted to any of the designs, so that full and final estimates can be obtained from local builders. To builders and architects residing in the country this work must prove invaluable.—*Manufacturer and Builder.*

ZELL'S POPULAR ENCYCLOPEDIA AND UNIVERSAL DICTIONARY. Philadelphia: T. Ellwood Zell. Part XI. 1869.

It is not many years since a comparatively small cyclopedia sufficed to contain exhaustive articles on almost every branch of human knowledge. How has all this changed! Some of our modern cyclopedias which deal with a single science contain as much matter as the first edition of the "Encyclopedia Britannica." At the same time, the tendency is toward condensation; and in the popular encyclopedias of to-day, we find dismissed in a single line a subject which a few years ago would have been expanded into a page. This holds particularly in relation to the well-known and deservedly popular cyclopedia published by the Messrs. Chambers, of Edinburgh. The same feature is prominent in the cyclopedia before us. In short, it combines the characters proper to both a cyclopedia and a dictionary. Thus we find not only such nouns as *ambition, ambler, ambling*, but adjectives like *ambitious* and adverbs like *amblingly*. On the other hand, such articles as ammonia are extended far beyond the limits of a mere definition, and present all the really valuable facts that are of interest to popular readers. We see that the editor has wisely avoided the futile attempt to supply the wants of professional men, who must, in all cases, rely either upon their own knowledge, or upon the assistance of purely technical works. We refer to such subjects as alcoholometry, alkalimetry, etc. In most popular cyclopedias, these purely technical departments of the chemist's art are either treated at an unreasonable length or described so superficially as to lead to error. The editor of "Zell's Cyclopedia" has avoided both these dilemmas. The publishers engage that the cost of the work, when completed, shall not exceed $25, and we know of no means of procuring the same amount of valuable information at such an easy rate.—*Manufacturer and Builder.*

SMOKING FIRES, THEIR CAUSE AND CURE. By the Rev. ALEXANDER COLVIN AINSLIE, M.A., Vicar of Corfe, Somerset. For sale by Van Nostrand.

"Where there is smoke there is fire," says the adage, but where there is smoke there is too often no light—to point out its cause or remedy—if the smoke be that of a house chimney. The puffing back, or even in some cases streaming back of smoke into a room, can be avoided or cured, and ought never to happen, though the fact is that there is scarcely a building even of the first class in which some of the chimneys do not smoke. That it is due in great part to the practical ignorance of first principles on the part of architects and housebuilders, and to the carelessness of both to almost everything but to getting "the job done and paid for," is certain.

Parson Ainslie has written by far the best treatise on the subject that has been produced. "The ascent of heated air and smoke is governed by certain known laws," he says in his introduction; "and the object of the following pages is to explain those laws as concisely as possible, and to point out the causes which most commonly modify or interfere with their action, and produce results apparently contradicting scientific theory." He does so in a brief and lucid manner, and then applies these laws to nearly all the examples of smoky chimneys occurring or likely to occur in practice, and deduces rules for guidance that even the least philosophical of bricklayers can scarce fail to comprehend and readily be guided by.—*Practical Mechanics' Journ.*

ANNUAL OF SCIENTIFIC DISCOVERY, ETC., FOR 1869. Edited by SAMUEL KNEELAND, A. M., M.D., etc. 12mo, pp. 377. Boston: 1869. Gould & Lincoln.

This old acquaintance is always an agreeable reminder of its predecessors of former years, as well as of numerous discoveries, facts and principles in various departments with which we are, as fellow laborers in the great field, more or less familiar, but which it is always pleasant to find marshaled in an orderly and compact manner, under their appropriate heads. Every such review of the year must of necessity be imperfect and unequal as an exposition of all that has been done, but even a cursory glance at Dr. Kneeland's Annual will show any fair-minded reader the vast variety of topics which now engage the attention of scientists, and the pains-taking care with which the editor has endeavored to present the most important results. The notes by the editor, forming an introduction to the volume, give an interesting summary of the progress of science for 1868.—*American Journal of Science and Art.*

MODERN SCREW PROPULSION. By N. P. BURGH, engineer. London: E. and F. N. Spon, 48 Charing Cross. For sale by D. Van Nostrand, 23 Murray street, New York.

Mr. Burgh's treatise on screw propulsion, which was to have been completed in fifteen parts, has been extended to sixteen. This extension has been decided upon in order that the work may embody some very recent important matter on screw propellers, which has been exclusively given to the author by our leading marine engineers. The author has thus exercised a wise discretion in thus extending his work, and to which none of his readers will object. Parts XIII, XIV and XV of this treatise are now before us; they are chapters on a new principle of the screw propeller, by Mr. Arthur Rigg, who has made some very interesting experiments with the screw, the results of which he here embodies. Mr. W. Langdon supplies a chapter on thrust blocks, and Mr. Burgh follows with another on the same subject. In Chapter XX, Mr. Burgh reviews comparatively the whole family of modern screw propellers as constructed by our principal marine engineers. In the succeeding chapter, Mr. Burgh gathers into a focus the opinions and ideas of all the engineers who have contributed to his treatise. In this chapter, the last page of Part XV finds us. The illustrations of these three numbers consist of lifting frames for the screw propeller, the feathering screw of the "Aurora," and the details of the methods of screw propulsion adopted in various other vessels.—*Mechanic's Magazine.*

THE PAINTER, GILDER AND VARNISHER'S COMPANION. Thirteenth edition, revised, with an Appendix. Philadelphia: Henry Carey Baird; New York: S. R. Wells, 389 Broadway.

This book contains rules and regulations in everything relating to the arts of painting, gilding, varnishing, glass-staining, graining, marbling, sign-writing, gilding on glass, and coach painting and varnishing. It also gives tests for the detection of adulterations in oils and colors, and a statement of the diseases to which painters are peculiarly liable, with remedies. It is several years since the first edition of the book was published, and as new editions have been gotten up, additions have been made to bring the work up to the time. The appendix added to the present edition comprises descriptions of a great variety of additional pigments, their qualities and uses, with additional information on dryers, and also contains an explanation of Chevreul's principles of harmony and contrast of colors.—*American Artizan.*

TREATISE ON THE POWER OF WATER. By JOSEPH GLYNN, F. R. S. D. Van Nostrand: New York, 1869.

(Second Notice.) We have had occasion, since receiving this book, to study the literature of water power, professionally and commercially. This fact, together with the corresponding fact that our difficulties have been solved by reference to this book, prompts us to acknowledge its merits in a more decisive form.

There are rules, in the professional pocket books, for measuring the *flow of water*, but it has been reserved for people who sell water, or pay for it, to observe a notable variation in the results of *position* and *shape* of orifices through which water is discharged. If all the information extant is not embodied in the work under consideration, there is enough to solve all ordinary cases.

In addition to the usual historical notice and to the wonted tribute to the power and functions of water, this book contains much interesting information upon the sources of water supply and upon water wheels. It is quite well illustrated and the subject appears to have been very carefully and exhaustively investigated by the author.

THE AMERICAN EXCHANGE AND REVIEW.—A miscellany of useful knowledge and general literature. Especially devoted to Finance, Mining and Metallurgy, Insurance, Railways and Transportation, Manufactures, Patents, Trade, Commerce, Art, Joint Stock Corporation Interests, Physics, Social and Economic Science. Fowler & Moon, 521 Chestnut street, Philadelphia.

This is a monthly of considerable value to students in the subjects mentioned above, and of no little interest to the general reader. It is a sort of connecting link between our literary and scientific serials. The department of mining and metallurgy is conducted by Prof. H. S. Osborn of Lafayette college, and is specially complete and interesting.

A SAPPER'S MANUAL, FOR ENGINEER VOLUNTEER CORPS. By Captain FRANKLAND, R. E. Published under War Office authority.

HINTS ON HOUSE DEFENCE AND BLOCKHOUSES. By Captain YOUNG, 18th Royal Irish. Wellington, New Zealand: Lyon.

MISCELLANEOUS.

SILVER PLATING—OLD AND NEW PROCESSES.—The following is compiled from the Birmingham correspondence of "The Engineer." The old-fashioned process was this:

An ingot of copper, ordinarily weighing about nine pounds, and which had an alloy of brass of one-fifth its weight, was first planed and then filed to a perfectly level surface on both sides; the ingot of silver, containing about 3 per cent of alloy, was rolled to the required thickness for the different qualities of metal to be plated. This was cut into suitable lengths, the weight of the piece of silver varying according to the quality, the lowest being about 16 dwts. for the 9 lbs. of copper for one side only, and increasing to 6 oz or 8 oz. The piece of silver was about $\frac{1}{8}$ in. less than the surface of the copper. It was scraped quite clean on the side next to the copper, great care being necessary that every imperfection should be removed; the two bright surfaces were then laid together and "bedded," by placing a heavy piece of iron on the silver, and striking it with a sledge-hammer till every part of the two surfaces touched. A strong piece of sheet copper was then laid on the silver, to keep it from rising during the process, and also to prevent the wires, which were used to bind the two pieces together from cutting the outer parts of the silver plate. A solution of borax was then laid round the edges of the silver to act as a flux. The ingot thus prepared was then heated in a small furnace until a bright line round the edges of the silver indicated that the union was effected. The ingot was then carefully removed from the fire and cooled gradually. When cold, the wires were cut, the copper plate taken away, the edges carefully

filed, and the plated ingot was then ready for the roller.

In the year 1840 the plated ware trade underwent a complete revolution. The process just described was superseded by an invention of Messrs. Elkington, now so well known as electro-plating, by which silver is deposited with accuracy and certainty by the aid of galvanism. This process is essentially dependent upon the original discovery of Volta, the alchemist, in 1799, on which various inventions had been subsequently based. Messrs. Elkington were, however, the first to apply the process successfully to the purposes of practical industry, and their enterprise in this direction took the old-fashioned platers by storm. The opposition they encountered was immense.

The process of plating at Messrs. Elkington's factory is thus described: The article having been thoroughly cleansed, it is plunged first of all into a solution of cyanide of mercury to prevent any oxidation, as well as to secure a perfect adhesion in the plating. It is then transferred to the plating vat, which is divided by plates of silver into regular compartments, the articles being suspended on brass rods with copper wire, and so arranged as to expose an equal amount of surface in each compartment to receive the deposit of silver. The operation of plating is so nicely regulated that the rate at which the silver is being deposited is correctly known, and the large amount of 24 oz. per hour is deposited, perfectly smooth and extremely hard. This, with the thickness of silver, accounts for the great durability of the articles manufactured by Messrs. Elkington. There are several large vats in use, so that some idea may be formed of the large amount of silver deposited in one day. When the article has been in the vat a sufficient length of time it is taken out, rinsed in cold water, and dried. After that it is carefully weighed, and the exact amount of silver on the article is at once seen and registered. In addition to the ordinary batteries used in plating, a very large magneto-electric machine is in constant work.

Asbestos Paper and Cloth.—The Florence correspondent of the New York "Times" (Mar. 27) gives a long account of this new manufacture. Crude asbestos resembles bleached hemp, with long, shining fibres, which may be twisted into threads and woven into cloth, or converted into pulp and made into paper. Asbestos is plentiful in various parts of Italy, and the new processes of treatment have been introduced there. The ancients, however, used asbestos cloth for embalming, and specimens of it are found at Pompeii. The great value of paper made from this substance is its indestructibleness, either by fire or by decay.

Heat of the Stars.—Mr. Huggins has been making experiments with the view of ascertaining the heat of the stars. He employed a thermopile, the face of which was placed in the focus of a telescope. The pile was connected with a galvanometer. The following results were obtained: The mean of a number of observations of Sirius, which did not differ greatly from each other, gives a deflection of the needle of 2°. The observations of Pollux 1¼°. No effect was produced on the needle by Castor. In one observation Arcturus deflected the needle 3° in 15 minutes. Regulus gave a deflection of 3°. The observations of the full moon were not accordant. On one night a sensible effect was shown by the needle, but at another time the indications of heat were excessively small, and not sufficiently uniform to be trustworthy. It should be observed that several times anomalous indications were observed, which were not traced to the disturbing cause. The results are not strictly comparable, as it is not certain that the sensitiveness of the galvanometer was exactly the same in all the observations; still it was probably not greatly different.

Magnesite or sepiolite, better known as "meerschaum," is found in masses in stratified alluvial deposits among serpentine. It is a product of the decomposition of carbonate of magnesia, its composition is silica 60.8, magnesia 27.1, water 12.1 in 100 parts. Meerschaum is found in Asia Minor in the plains of Eskii-Sher or Eski-Schehir, in Greece, at Egribos in the island of Negropont, in the isle of Samos, at Kiltschik in Natolia, in the Crimea, at Hrubschitz in Moravia, in Morocco, at Vallecas in Spain (where it is used as a building stone), at Baldissero in Piedmont, in Cornwall, in France (in the departments of the Gard, of Seine et Marne, and of the Seine); but the most remarkable quarries worked at present are situated at Brussa, at the foot of Mount Olympus. When first dug up it is damp, soft and greasy. The Tartars use it as soap to wash linen, and the Arabs of Algeria in the manner in the Moorish baths. In masses it floats on water. The color is grayish-white, white, or with a faint yellowish or reddish tinge.

Coal Ashes as a Fertilizer.—A series of experiments conducted at the Museum of Natural History, Paris, during the past year, by Professor Naudin, on the value of coal ashes as a fertilizer, has resulted in the conclusion that they are neither a manure nor even earth of the most infertile quality. An opinion to this effect has prevailed in this country pretty generally, but it is certain that upon heavy clays, they act as a disintegrator if nothing else. This effect is not, we are convinced, merely mechanical, as a very small amount of coal ashes is sufficient to destroy the adhesiveness of a large amount of clay. At least this was the case in a recent experiment of our own, tried in accordance with the advice of one of the most accomplished florists in New York State. By the application of sifted coal ashes with a very small proportion of well rotted horse manure, we were able to make a thrifty flower garden the first season, upon one of the stiffest soils it has ever been our lot to own.—*Scientific American.*

Mr. Andrew Shanks, inventor of the double slotting drill, and designer, and maker of much heavy and ingenious machinery, well known in England, died recently at Hastings. "Engineering" says, and we can certainly indorse the following: "His universal readiness to assist in carrying out improvements, or afford information on engineering subjects, are too well known to all who ever had occasion to apply to him, and his death, with such a vast amount of unrecorded practical information, must be regarded as a serious loss."

Boiler Explosions.—During the past seven months there have been in the United States sixty-one boiler explosions, the great majority of them involving loss of life.